



Living with

END-STAGE RENAL DISEASE



A BOOK FOR PATIENTS

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
HEALTH SERVICES ADMINISTRATION

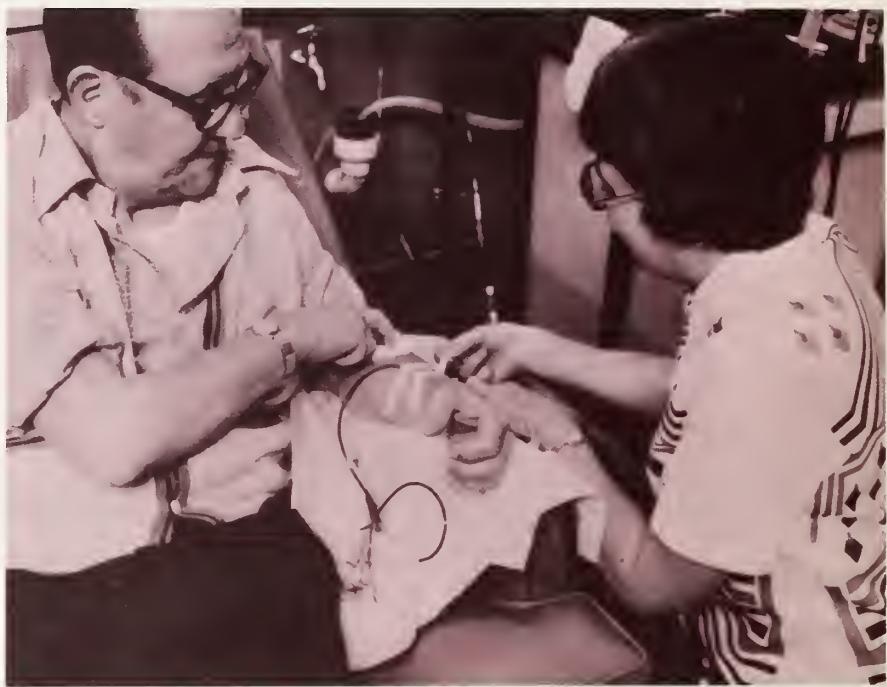
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BUREAU OF QUALITY ASSURANCE



Patient on home hemodialysis

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Preface

IN NOVEMBER, 1972, Public Law 92-603, Section 299I amended the Social Security Act to provide Medicare coverage for persons with end-stage renal disease. Under the kidney disease provision of the Act, you are eligible for Medicare coverage if you have end-stage renal disease requiring either maintenance dialysis treatments or a kidney transplant and if you have the required social security or railroad retirement work credits. Dependent children are also covered.

Because of the complexities of treatment and the need for maximum patient participation in the planning and administration of such treatment, it became apparent that an information source should be available for all persons with end-stage renal disease.

The Bureau of Quality Assurance of the Department of Health, Education, and Welfare contracted with the National Kidney Foundation (Contract No. HSA 105-74-22) to produce a publication which would explain some of the medical aspects of end-stage renal disease and some of the technical procedures of the treatments, maintenance dialysis and transplant surgery. The National Kidney Foundation, working with a core committee and an advisory group, has produced this publication for you.

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Introduction

This publication emphasizes your importance in the treatment of End-Stage Renal Disease. Since this condition requires daily care, your doctor cannot fulfill all medical needs. Therefore, it is *your* participation in treatment that will bring you better health. Use this publication as a reference manual to treatment, and discuss any questions with your doctor. Share the publication with members of your family. The more you know about your health care, the better you will understand the care you will receive.

Although your kidneys are no longer functioning properly, there are methods of making up for their inability to function. End-Stage Renal Disease is a serious disease, but there is much that can be done to maintain your health, and help you lead a full, rewarding life.

The two major treatments for End-Stage Renal Disease are dialysis and kidney transplantation. This publication will discuss both treatments to help you understand your therapy and to introduce you to the role you will have in your medical care.

The goals of this book are:

- To explain some of the medical aspects and technical procedures of your treatment.

- To emphasize the many ways in which physicians and other members of the health care team may assist you
- To help you recognize and cope with the major changes in your life which may result from your treatment
- To describe ways you can assist in your health care and maintain as much independence as possible

This publication discusses some of the medical aspects of End-Stage Renal Disease. Two publications on the financial aspects are available from your local social security office. They are entitled *Your Medicare Handbook* and *Medicare Coverage of Kidney Dialysis and Kidney Transplant Services: A Supplement to Your Medicare Handbook*.

Treatment of End-Stage Renal Disease involves more than controlling your disease. One of the major goals of treatment is rehabilitation. Through treatment, most patients should be able to lead productive and active lives. You will have to expend much effort to maintain your health, but this should result in greater enjoyment of the many activities that give you pleasure and satisfaction.

The Function of The Kidneys

NORMAL KIDNEY FUNCTION

YOUR BODY must maintain the proper chemical balance in order to function properly. Certain chemicals must be kept in the bloodstream in the correct amounts, and other chemicals must be removed from the bloodstream. The chemicals that must be removed are often called *metabolic endproducts*. ("Metabolic" refers to all the chemical processes of the body. "Endproducts" are chemicals produced by metabolic processes, many of which are not required by the body.)

The kidneys, which help to maintain the body's chemical balance, have four main functions:

1. To rid the body of excess fluid
2. To rid the body of metabolic endproducts
3. To retain the amount of fluids needed by the body, and to retain the chemicals necessary to the body
4. To release into the bloodstream hormones that help control blood pressure and blood production.

If the kidneys do not function properly, metabolic endproducts will build up in the bloodstream, resulting in a condition called *uremia*. The symptoms of uremia include weakness, fatigability, vomiting, nausea, generalized itching of the skin, and sleep disturbances. Severe uremia may cause nosebleeds, intestinal bleeding, impaired memory, confusion, and emotional instability. Other symptoms of End-Stage Renal Disease include shortness of breath, swelling of ankles, and poor appetite.

Figure 1 is a diagram of the urinary system. The two bean-shaped organs are the *kidneys*. Two tubes called the *ureters* lead from the kidneys to the *bladder*, a storage sac for urine. A tube called the *urethra* leads from the bladder to the opening from which you urinate. When the bladder is full, nerves in the walls of the bladder signal the brain,

so that you can urinate at an appropriate time.

In an adult, each kidney is about the size of a fist and weighs approximately one third of a pound. A single unit of the kidney that acts to maintain the chemical balance of the body is called a *nephron*, which is shown in Figure 2. Each kidney contains about one million nephrons.

Blood is carried to all parts of the body through the arteries and veins. Blood enters the kidney through the *renal artery*. ("Renal" refers to kidney) In the kidney, blood passes through the nephrons, which act as filters and remove excess fluid and metabolic endproducts. The excess fluid and metabolic endproducts are then eliminated from the body as urine, and the blood passes through the kidneys back to the circulatory system. In one day, about two hundred quarts of blood pass through the kidneys. Of this amount, about two quarts of excess fluid and metabolic endproducts are removed and eliminated when you urinate.

If called upon, each kidney can do much more work than it ordinarily would do. If a person were to lose one kidney through injury, disease, or through donation for transplantation, the remaining kidney would increase in size and do the job of two kidneys.

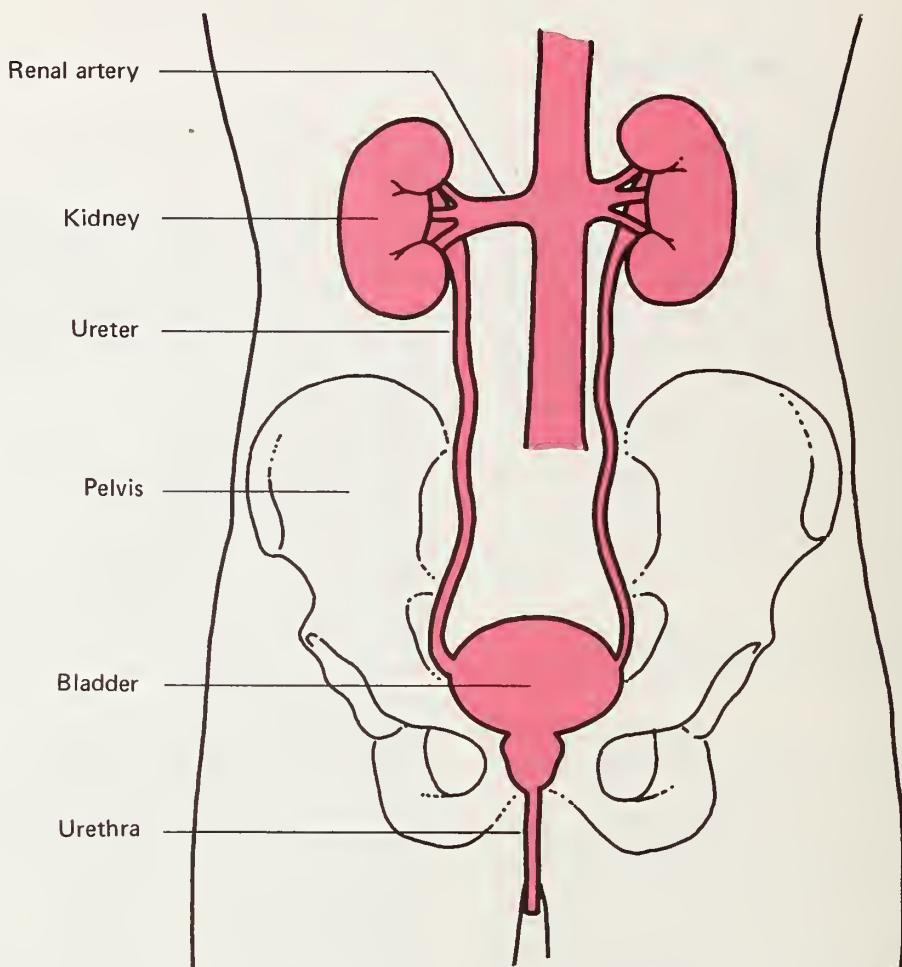
WHEN NORMAL KIDNEY FUNCTION STOPS

There are two types of kidney failure, called *acute* and *chronic*. The main differences between acute and chronic kidney failure relate to how rapidly the process occurs, the causes of the kidney failure, and the duration of the kidney failure.

Acute Kidney Failure

This is a rapid stopping of kidney function which occurs in a matter of hours or days.

Figure 1. Urinary system



There are many possible causes of acute kidney failure, including severe shock and reduced blood supply to the kidneys (as in internal bleeding or multiple body injuries), certain types of poisoning, specific types of glomerulonephritis (a kidney disease), and injury to or blockage of the blood vessels leading to the kidneys.

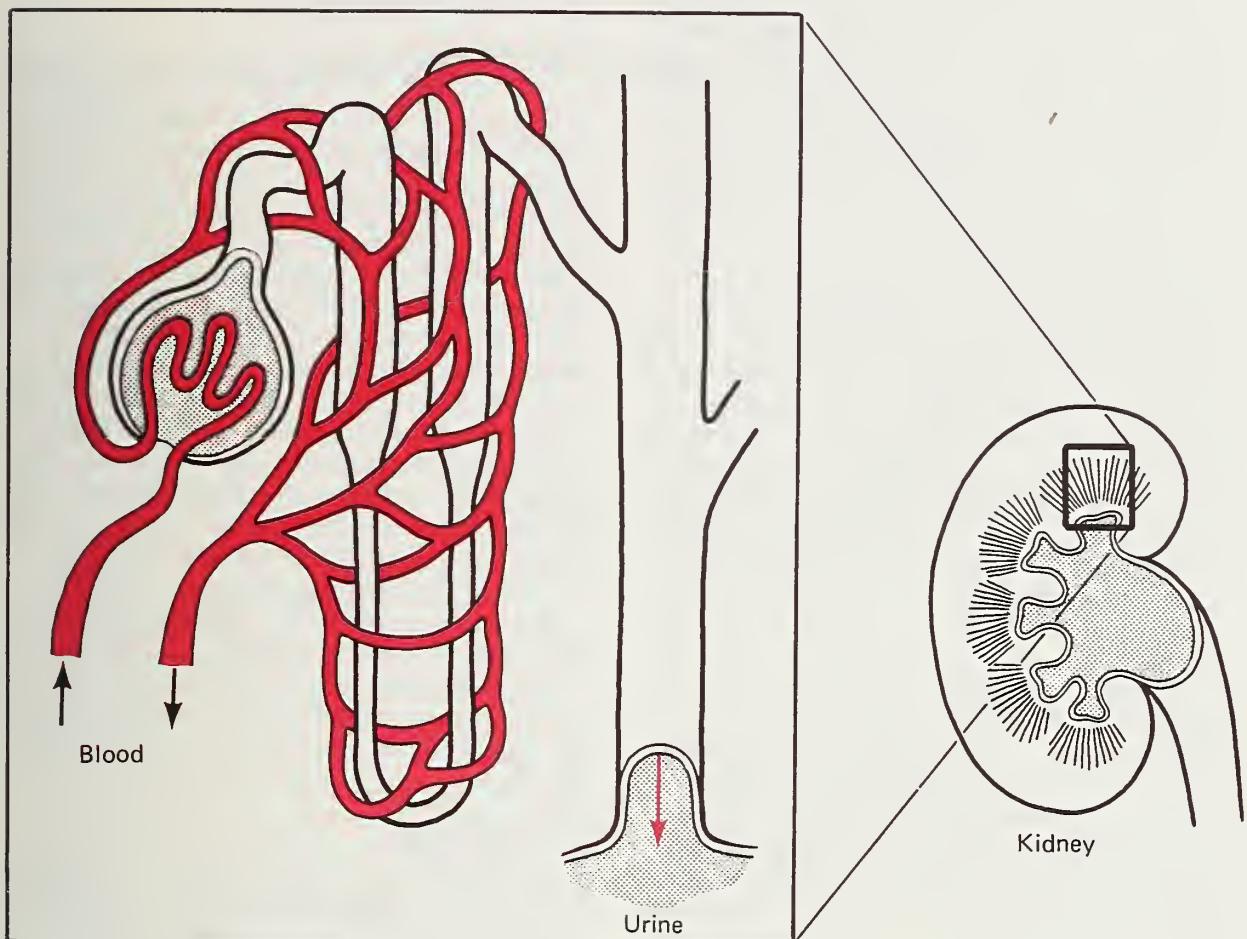
In most cases of acute kidney failure, the function of the kidneys is restored naturally within several weeks. Dialysis is required in most instances for a period of only a few weeks if kidney function returns. In some cases the kidney failure is permanent and therefore, it becomes chronic.

Chronic Kidney Failure

Chronic kidney failure differs from acute in that destruction of normal kidney tissue occurs over a longer period of time. Most patients with chronic kidney failure have no symptoms until far more than half of kidney function is lost. At this point, high blood pressure, fatigue, weakness, or low blood count may first be detected. In many cases an analysis of the urine or blood will detect abnormalities sooner, but many patients go undiagnosed since they have no symptoms and do not seek medical evaluation.

When kidney function reaches approxi-

Figure 2. Nephron



mately five percent of normal, or when 95 percent function has been lost, dialysis or transplantation is required to prevent progression of symptoms and maintain life. There are many possible causes of chronic kidney failure, which may be inherited or acquired in childhood, adolescence, or adult life. Polycystic kidney disease is an example of an inherited disease that may lead to kidney failure in the middle adult years. The most common type of kidney disease leading to chronic kidney failure is chronic glomerulonephritis in which there is an inflammation of the small filtering units of the kidney. Chronic kidney failure may also be pro-

duced by long-standing diabetes and high blood pressure.

THE IMPORTANCE OF DIET

Since kidney failure includes the inability to excrete certain metabolic endproducts produced by the body from the foods we eat and the fluids we drink, it is important to control the amount and types of food you eat to help reduce the quantity of metabolic endproducts that the body produces. For example, when only 30 to 40 percent of normal kidney function remains, restricting protein, and meat in particular, can reduce

the amount of urea produced by the body. Sodium, an element found in table salt and many foods, may have to be restricted as urine volume decreases and if high blood pressure and fluid retention develop. Foods containing potassium, especially fruits and vegetables, must be measured carefully when kidney function is less than 15 to 20 percent of normal. Your doctor or dietitian will give you detailed diet instructions and will help answer your questions.

Dietary control is the earliest and most important form of therapy that you must accept in your changing lifestyle. Although many patients find this adjustment very difficult at first, the body usually adapts in many ways and your desire for the medically undesirable foods may change to the point that they no longer taste pleasant. In general, patients who make an early adjustment to their changed diet do better medically.

PREVENTION AND RESEARCH

At this time, some, but not all, types of kidney disease can be prevented if detected in their earliest stages. Research into prevention and treatment of kidney disease is continuing, but not enough is known yet to determine how to prevent many forms of chronic kidney disease.

TREATMENT OF KIDNEY FAILURE

Since you have end-stage renal disease you should fully understand the treatment that will help substitute for functions normally

performed by your kidneys. This treatment will be either ongoing dialysis or transplantation of another kidney.

Hemodialysis

Hemodialysis is a method of using an artificial kidney machine to remove fluids and metabolic endproducts from the bloodstream.

Blood is taken from a blood vessel in the arm or leg through a needle inserted in an internal fistula, or through the cannula of an external shunt. The fistula and shunt are explained in more detail later. Following insertion in the blood vessel, the needle or cannula is attached to a tube which carries blood to the artificial kidney hemodialysis machine. The patient's heart pumps blood through the tube to the machine where the blood is treated. Then the blood is returned to the body through another needle that has been inserted into the vein.

The time needed for hemodialysis varies for different patients, but a typical patient would have two to four sessions a week, each session lasting from three to eight hours. Hemodialysis is discussed in detail in Chapter Three.

Transplantation

Transplantation may be a more familiar term to you. Transplantation involves removing a kidney from a living relative, or from a cadaver, (body of someone who has just died), and implanting it through surgery into the (kidney) patient's body so that it will perform the functions of a normal kidney. Transplantation will be discussed in more detail in Chapter Four.

Adjustment To End-stage Renal Disease

CONFRONTING and dealing with your kidney condition may well be one of the greatest challenges you have ever faced. You will be asked to cope with treatments, environments, and feelings you may never have experienced before. Many people before you have found that this is a situation that they can manage, and most of them are doing well. But there are problems that you will probably experience in the near future.

This chapter will try to prepare you for some of these problems. More importantly, it will suggest some of the sources of help available to you to deal with these problems.

One of the biggest problems you may have is convincing yourself that you truly have end-stage renal disease. When you first were told that you had renal disease, your reaction may have been disbelief. You may not have felt seriously ill, and the idea that you had an incurable disease probably was shocking. Many patients with end-stage renal disease report that their first reaction was denial. They refused to believe what their doctors told them and rejected the diagnosis. This denial may influence the exactness with which you take your medicine, follow your diet, and do all of the things which are important for you to do.

Many times after beginning treatment you may feel angry. You may dread the thought of another dialysis treatment or surgery, and find yourself expressing anger at doctors, nurses, other staff, your family, and yourself. Anger or depression in this situation is natural. You have a right to feel the way you do. However, sharing your feelings will make it easier for others to understand how you feel and act.

A problem may also arise in your relationships with your family in your new situation as an end-stage renal disease patient. Over the years, your family members have learned to relate to you in certain ways. Having kid-

ney disease means that you have changed in some ways. You may be weaker, more listless, and more irritable. These changes may express themselves as resentment and hostility in your family relationships. These changes may also make it difficult for the people close to you to talk with you and tell you what they really think about things.

A particularly sensitive problem that you may have to deal with involves your sexual life. Chronic disease can reduce the desire for sex, and chronic renal disease may restrict your capacity to perform certain sexual activities. This can result in difficulties and poor self image. It is important to keep in mind that the capacity to perform sexual acts is only part of being a sexual person. Sexuality is primarily a way of expressing the deeper feelings people have for each other. If the desire is reduced, even temporarily, because of disease and your sexual partner does not realize this, the partner may think that you no longer care. It is easy to see how this could disturb relationships in everyday living.

End-stage renal disease may also present problems in your work. Some people remain in the same job while others do not. For example, if you are engaged in heavy physical work or work exceptionally long hours, your illness may make it difficult or impossible to return to the same job. If you are able to return to your job, you may find that you are denied promotions or asked to accept reduced responsibilities. If you have not yet started your career, you may find that you are excluded from certain types of work. The job situation can have an impact on your self-esteem and your morale and your financial state.

Your hobbies and leisure-time activities can also be affected. Contact sports, such as football and wrestling, are not recommended. All recreational activities, even watching

television and reading, may not seem as enjoyable if you are worried or pre-occupied and find it hard to concentrate. This may be especially true at the beginning of your illness.

Every patient at one time or another feels irritable, blue, nervous, or depressed. You can not avoid feeling frustrated when you can no longer do the things that you used to do well. These unpleasant feelings actually become another problem because it is hard to do things and to build a new life when you are emotionally upset.

Reading this chapter so far may have made you feel discouraged. But, you may know by now that these are indeed real problems which you have experienced. At the present time, you are no doubt experiencing the most difficult part of your illness. Most patients feel as bad as you at first, but after a short period of time, usually by the end of four to six months in treatment, people feel better.

As you feel better, a good kind of "snowball" effect starts to take place. The better you feel, the better you will be able to handle the problems that arise, and the fewer problems you will have. Periodically you can expect to have episodes of discouragement and depression, but usually these will be shorter than what you are now feeling.

SOURCES OF HELP

It is almost as unreasonable for you to handle your emotional problems without assistance as it would be for you to handle your medical problems alone. An immediate source of help available to you is your health-care staff. They know that your life may be in turmoil. They want to assist you. It is important for you to share fully with them how you feel and what is happening to you.

In addition, there are people on the team who are experienced in counseling. Many units have a social worker, a psychologist, a psychiatrist, or all of these personnel available for their patients. They have interest and knowledge in the emotional reactions that

people experience when they have end-stage renal disease. They are ready to help you "get it all together."

Of great help will be the support that your family members can give you. The treatment of end-stage renal disease probably involves the family more than any other type of disease. It is important that you and your family share feelings about your disease.

Other patients and their families can be sources of help and encouragement. Since you may not be feeling well right now, it may be hard to believe that you will ever feel well. You may find yourself thinking that this is easy enough for healthy doctors and nurses to say but they don't have renal disease. But you will be meeting many patients who have been through exactly what you are experiencing and they will be very willing to share their experiences and successes with you.

In addition to individual patients, groups of end-stage renal disease patients have joined together, frequently with family members, to form self-help groups with the purposes of sharing their experiences, problems, and solutions.

Local chapters of the National Kidney Foundation can be a resource to you in finding out about organized groups of patients in your area or about individual kidney patients who would like to talk with you.

There are two nationwide consumer organizations, formed by patients with end-stage renal disease. Both send periodicals and other information to their members. They are AKP, The Association of Kidney Patients, and NAPHT, The National Association of Patients on Hemodialysis and Transplantation.

Finally, the most important source of help is you, yourself. Just as in most problems people face, it is the individual himself in the final analysis who will make the decisions and take the actions that will lead to solutions.

All the people named above are available for help, but it is your effort that will be most important in drawing all the strings together and constructing an effective new life.

Dialysis

DIFFUSION, OSMOSIS, AND ULTRAFILTRATION

THE FUNCTION of the hemodialysis machine is based upon the principle of *dialysis*—dialysis separates from your body the things that are not wanted. Dialysis is a process that begins when two solutions are separated by a membrane. A solution is a liquid containing a dissolved substance; a membrane is usually a very thin layer of tissue. In a hemodialysis machine, the membrane used is a type of cellophane. To understand dialysis, you should understand three processes that occur in the hemodialysis machine. These are *diffusion*, *osmosis*, and *ultrafiltration*.

Diffusion is the movement of *particles* from one solution with a high concentration to another solution of lower concentration. Concentration refers to the number of particles dissolved in a solution. A solution of high concentration has more particles dissolved in it than does a solution of lower concentration. For instance, if you dissolved two spoonfuls of salt in a glass of water, this solution would have a higher concentration than if you dissolved only one spoonful of salt in the same glass of water.

Osmosis refers to the movement of *liquid* through a membrane from a solution of lower concentration to one of higher concentration. Osmosis and diffusion occur at the same time.

If you fill a cellophane bag with a salt solution (salt dissolved in water), seal it, and put the bag in a container of pure water, as shown in Figure 3, the pure water will become salty, and the solution in the bag will become less salty. This happens because the cellophane has millions of tiny holes called pores. The particles of salt are small enough to pass (diffuse) through the pores and into the pure water. Particles can pass back and forth between the two solutions, but more pass from the solution of higher concentration to the solution of lower concentration. This is the process of diffusion.

While particles in solution tend to pass from areas of high concentration to areas of lower concentration, the water tends to pass in the opposite direction from a solution of low concentration to a solution of high concentration. In the solution containing less salt, there is more water. Therefore, water will tend to move in the opposite direction from that in which the particles tend to move. This passage of fluids through the membrane is osmosis.

Ultrafiltration is important in removing fluids from a solution. If the solution on one side of a membrane is under greater pressure than the solution on the other side, the extra pressure will tend to force fluids through the membrane toward the solution at lower pressure.

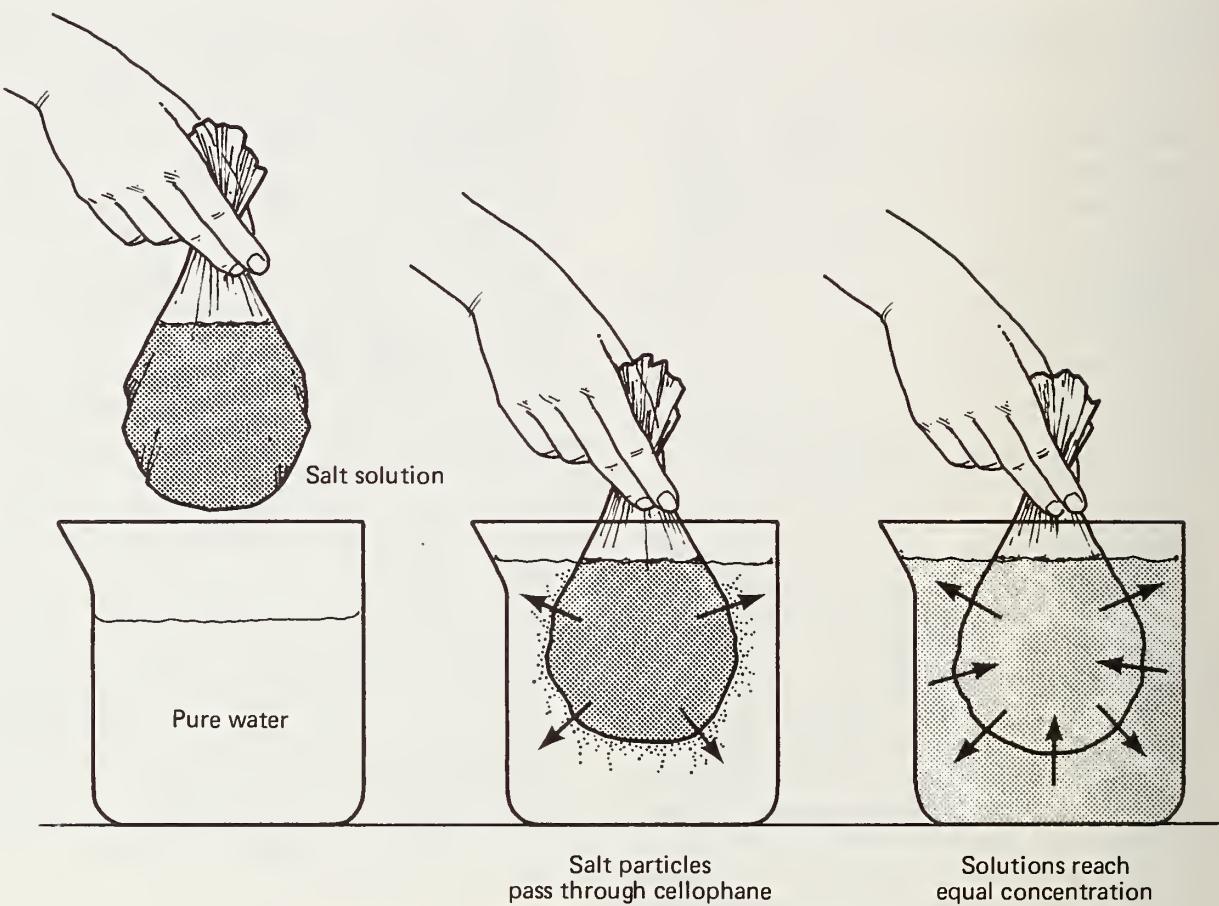
If a cellophane bag were placed in the container of water with the top of the bag open, and pressure were exerted on the water inside the bag, as shown in Figure 4, this pressure would tend to force water through the membrane out of the bag.

In hemodialysis, diffusion, osmosis, and ultrafiltration occur at the same time, but they are illustrated here in three diagrams.

Diffusion

Figure 5 illustrates the principle of diffusion. In many hemodialysis machines, the dialysis membrane is in the form of a long cellophane tube. The large circle in the diagram represents a cross section of this tube. Your blood is on the inside of the cellophane tube; the dialysis bath (dialysate) is on the outside. As blood comes into contact with the inside of the dialyzing membrane, certain metabolic endproducts, such as urea and creatinine, which are dissolved in the blood in high concentration will then pass (diffuse) from the blood through the membrane into the dialysate since the dialysate does not contain metabolic endproducts. The dialysate into which these endproducts

Figure 3. Diffusion



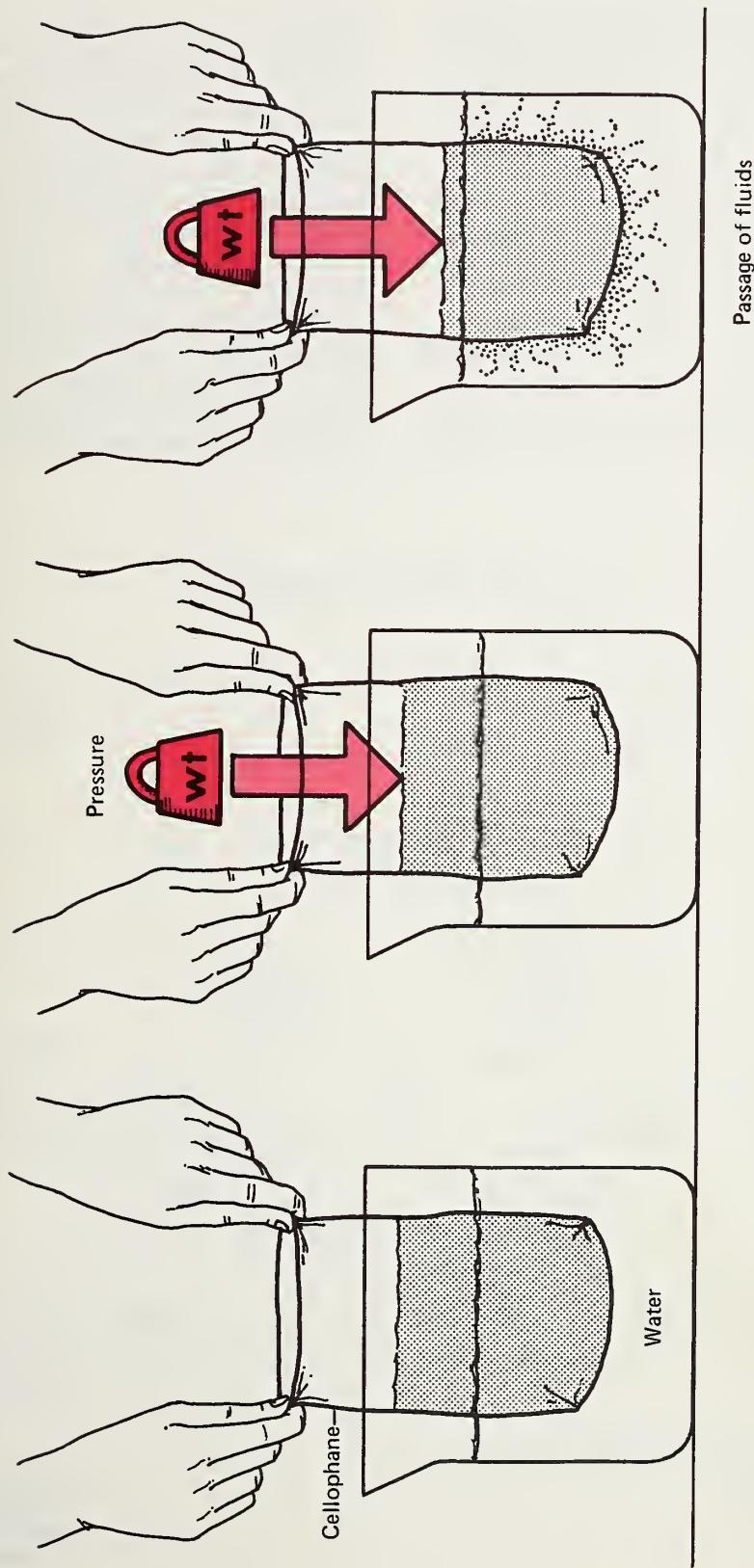
have diffused will then be washed away by a fresh dialysate solution so that it can be removed from the hemodialysis machine. Thus, metabolic endproducts can be eliminated from the body by continuous circulation and removal of the dialysate. In Figure 5, the dots, representing metabolic endproducts (including urea and creatinine), is shown to cross the dialyzing membrane into the dialysate where the endproducts will eventually be removed from the hemodialysis machine. Since fresh dialysate solution is constantly flowing through the hemodialysis machine and coming into contact with the

dialysis membrane, the process of removing metabolic endproducts is a continuous one as long as your blood continues to flow into the hemodialysis machine.

Blood elements, such as red blood cells and white blood cells, are too large to pass through the dialysis membrane and do not leave the bloodstream.

Removal of metabolic endproducts by the process of diffusion is only one part of the hemodialysis process. If there are substances, such as calcium or dextrose, that are in higher concentration in the dialysate than in the blood, these substances will diffuse from the

Figure 4. Ultrafiltration

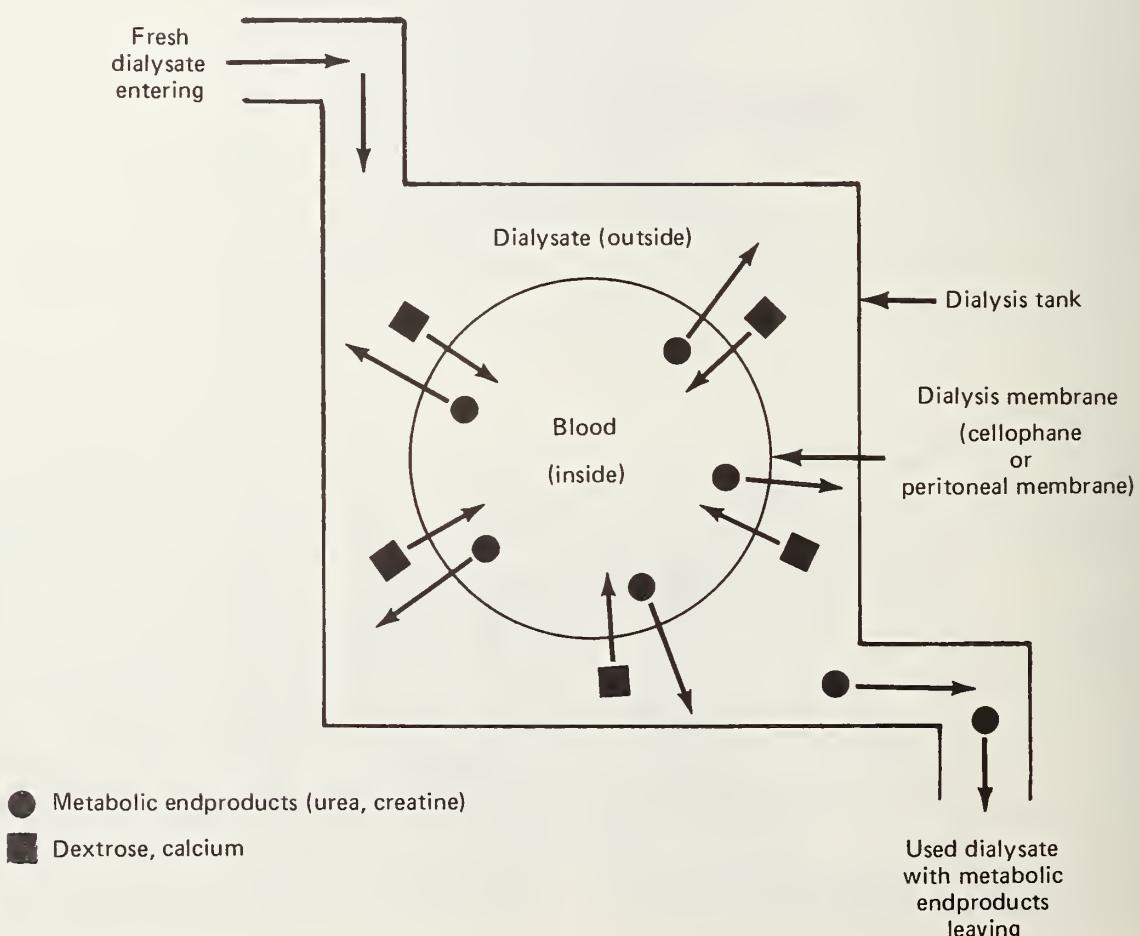


dialysate through the dialyzing membrane to the blood and result in an addition of these substances to your blood. This is shown in Figure 5, where the squares represents those substances, such as calcium and dextrose, which have a higher concentration in the dialysate than in the blood. These will move by diffusion from the dialysate across the membrane into the blood resulting in an addition of these substances to your blood. Once the blood has lost its metabolic end-products and has received certain substances from the dialysate, it is returned to you. Thus, diffusion across the dialyzing membrane can occur in both directions.

Osmosis

The process of osmosis can be used to remove excess fluids from your body during hemodialysis but it is more important in peritoneal dialysis. In principle, osmosis is a specific form of diffusion involving the movement of fluid (water) rather than specific dissolved particles. In hemodialysis or peritoneal dialysis, water will move from the blood, which has a lower concentration of dissolved particles, to the dialysate, which has a higher concentration of dissolved particles. The high dialysate concentration is maintained by adding dextrose to the dialysate solution before it is passed either into

Figure 5. Diffusion during dialysis



the hemodialysis machine or the abdominal cavity. Therefore, water will move from the blood across the dialysis membrane into the dialysate by osmosis where it will then be eliminated with the dialysate. At the same time, some dextrose will move by diffusion from the dialysate to the blood. In Figure 6, the large circle represents the dialyzing membrane (cellophane in hemodialysis; peritoneal membrane in peritoneal dialysis), the dots represent water, and the squares represent dextrose. Water is added to the dialysate by osmosis at the same time dextrose is added to the blood by diffusion. This results in fluid loss from your body and addition of some

dextrose to your bloodstream.

Osmosis can also be used to remove excess fluids from the blood during hemodialysis, but it is more important in peritoneal dialysis. If, as in Figure 6 dextrose (sugar) is added to the dialysate, fluid will move from the blood, which has a lower concentration of dextrose to the dialysate, with the higher dextrose concentration. Some dextrose will move from the dialysate into the blood.

Ultrafiltration

If *ultrafiltration* is used during hemodialysis to remove fluids from the blood, a pump is added to the hemodialysis machine

Figure 6. Osmosis during dialysis

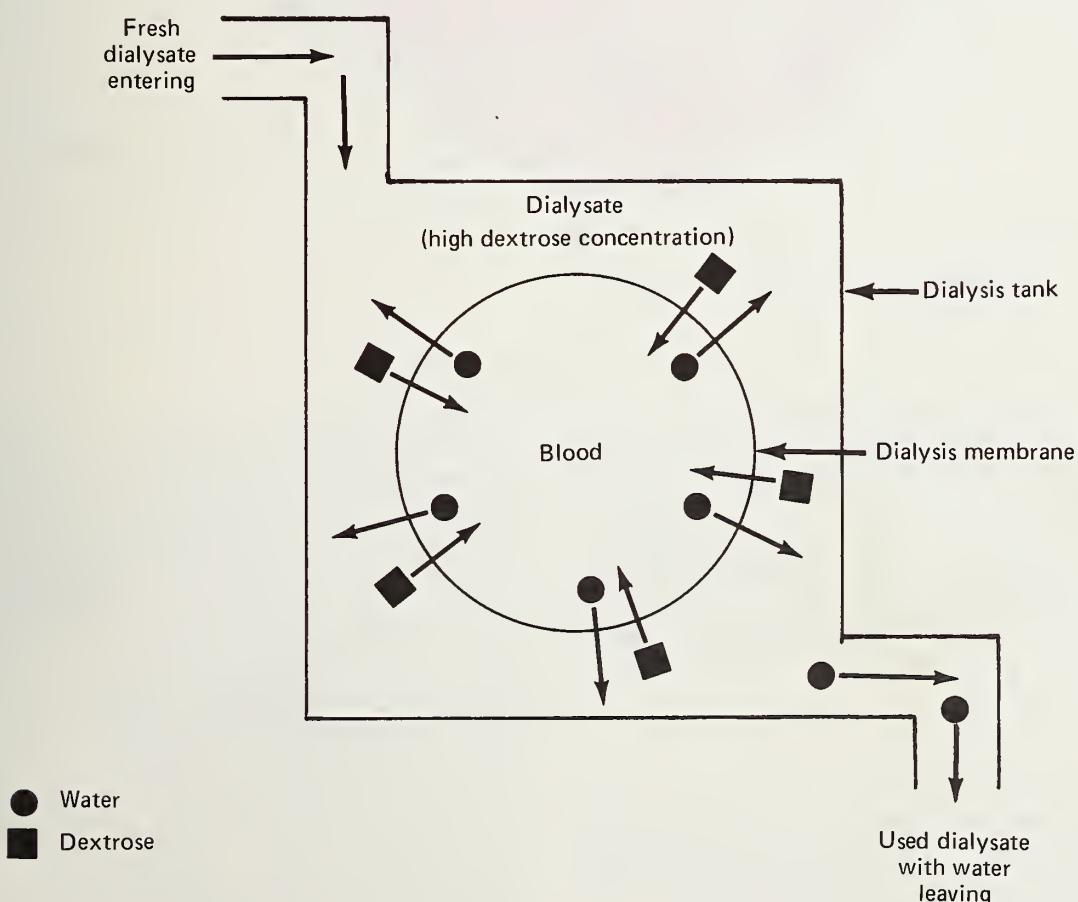
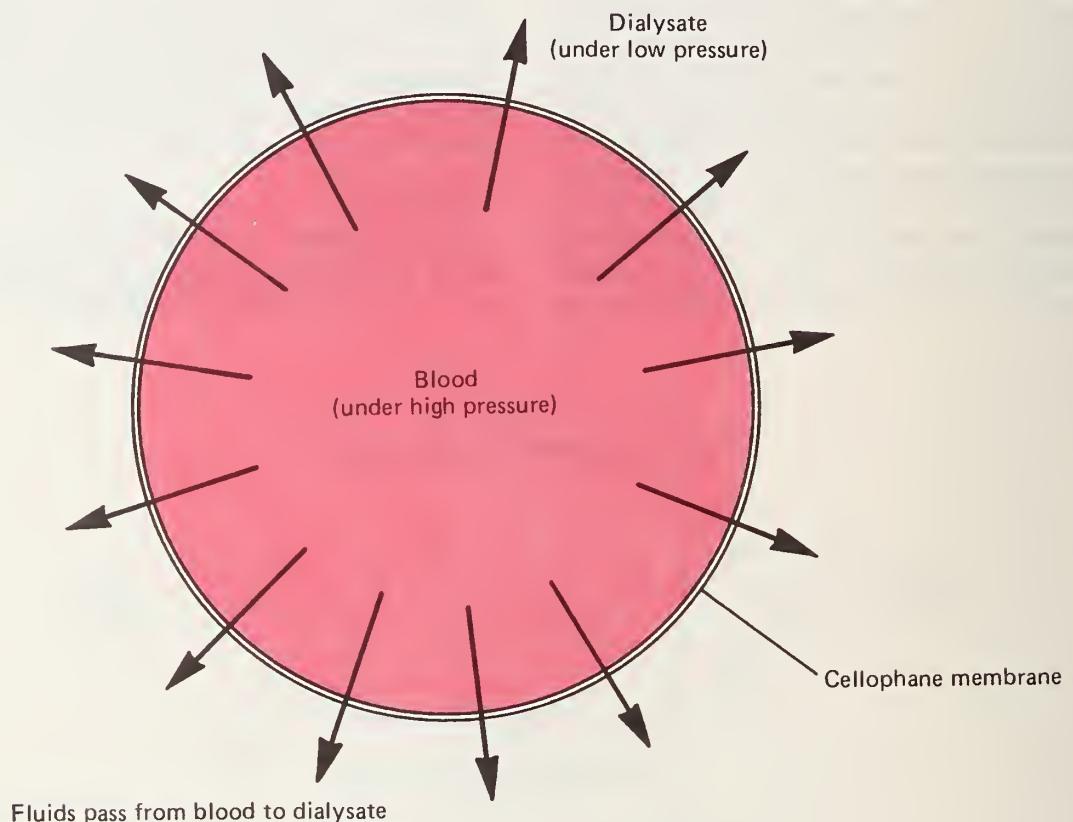


Figure 7. Ultrafiltration during dialysis



that will pump the patient's blood into the dialyzer. This will raise the pressure of the blood above that of the dialysate, and fluids will be forced out of the blood through the dialysis membrane as shown in Figure 7. A similar effect can be obtained by lowering the pressure of the dialysate through the use of suction. This is called "negative pressure" and is the method of fluid removal in certain types of dialyzers.

SHUNT AND FISTULA

There are two methods of getting blood from your body to the hemodialysis machine and back to your body again. These are an *external shunt* and an *internal fistula*.

External Shunt

An external shunt consists of special tubes that carry blood from an artery directly to a nearby vein. This is shown in Figure 8. The small tubes that are placed in an artery and nearby vein are called "vessel tips" or "cannulae". One cannula is inserted into an artery in your forearm, and the other into a vein nearby, also in your forearm. (An artery carries blood rich in oxygen from your heart to your body tissues. A vein carries blood back from the tissues to your heart.) During hemodialysis, the cannula in your artery is attached to a tube carrying blood to the artificial kidney. The cannula in your vein is attached to a tube that carries blood back to your body from the artificial kidney.

The cannula remains in your arm at all times, even between treatments. Occasionally, cannulae may be inserted into a vein and artery in your lower leg, instead of in your forearm.

While a person with an external shunt is on the artificial kidney, his arm must be kept still to avoid pulling the cannulae loose. Between hemodialysis treatments, the cannulae are joined by a tube called a connector, and a bandage is worn over the area to protect the external shunt from infection or injury, and from being dislodged.

An external shunt requires extreme care. It is important to keep the bandage securely in place to prevent infections and to prevent the external shunt from being pulled out. If infection occurs, it may be accompanied by redness, pain, swelling, or drainage around the area of the cannulae which may result in

fever. Call your doctor if you experience any of these symptoms.

A blood clot can form in the external shunt. You should check the color of the blood flowing through the external shunt several times a day. It should be rose-red. If the blood becomes dark bluish-red, a clot may have formed and you should call your doctor immediately. Sometimes you can see a blood clot in the external shunt, or you can see that the blood has separated into dark and clear fluids. If this happens, contact your doctor or hemodialysis center.

Internal Fistula

An internal fistula (under the skin) is a connection made between an artery and a vein within the arm or leg by a minor surgical procedure. An artery carries blood moving at a fast rate and under high pressure; a

Figure 8. External shunt

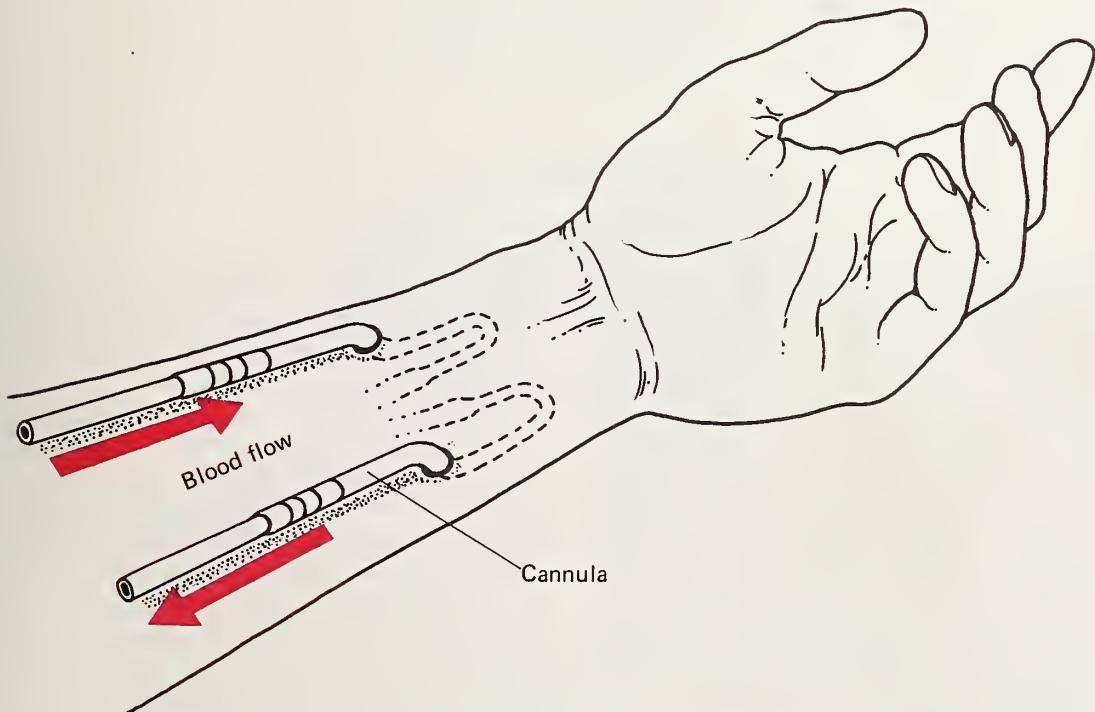
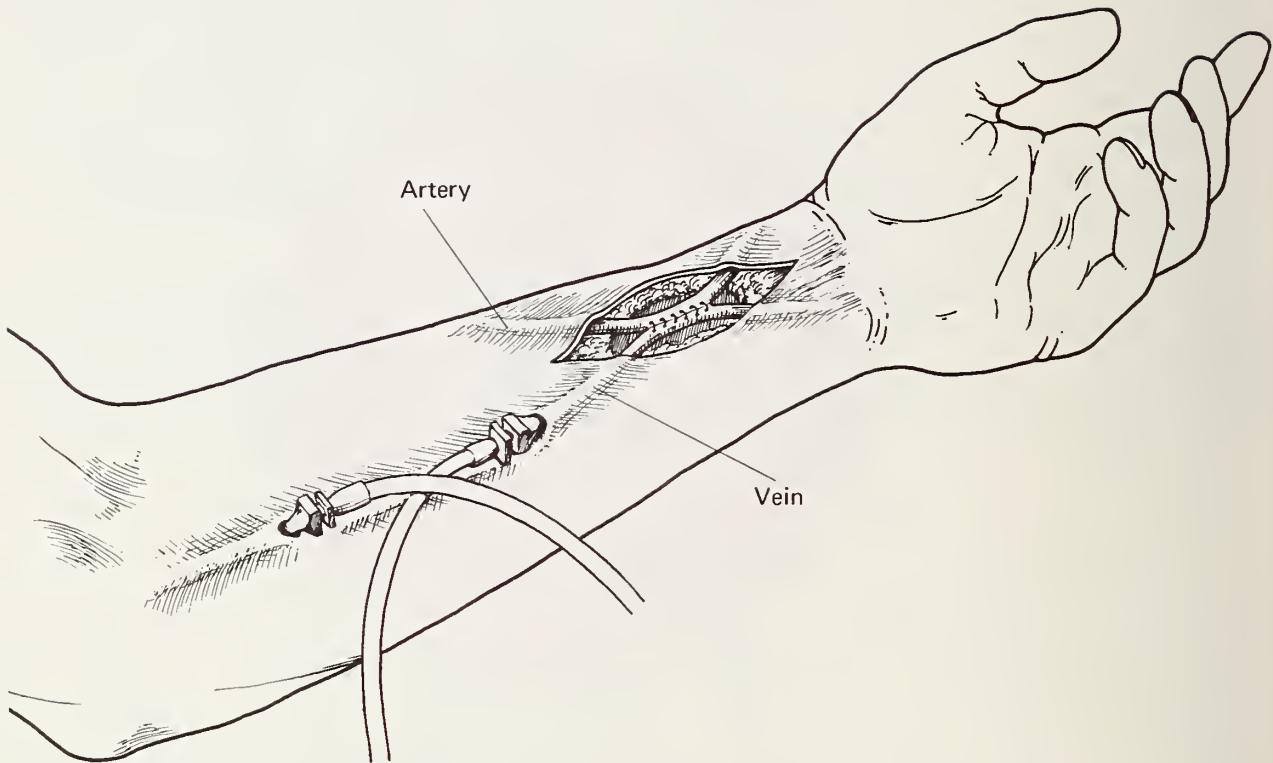


Figure 9. Internal fistula



vein carries blood at a slower rate and at lower pressure. In an internal fistula, an artery is connected to a vein so that blood is carried directly from the artery to the vein, bypassing many small blood vessels in the area. When blood from an artery flows directly into the vein through the internal fistula, the vein becomes larger. During dialysis, two large, hollow needles can easily be inserted into the enlarged veins. The needles are attached to tubes, which carry the blood to the hemodialysis machine and then back to the body. Figure 9 shows how the internal fistula is made and how the needles are inserted during dialysis.

One advantage of an internal fistula is that

it requires no special care between hemodialysis treatments. You do not need to bandage an internal fistula, and there is no danger of its coming loose.

After an internal fistula has been made, it takes several weeks for the veins to become large enough so that they may be easily entered by needles. Your doctor may give you special instructions about helping the fistula veins enlarge so they can be used.

Before a hemodialysis treatment, the area of the internal fistula is cleaned. A nurse, technician, or the patient then numbs the skin with novocaine and inserts the needles painlessly.

Internal fistulas can also become clotted,

although much less frequently than external shunts. Signs of clotting include disappearance of the vein's pulsation; disappearance of the sound produced by the moving blood, pain and swelling. If you notice any of these signs, contact your physician or dialysis center immediately.

TYPES OF HEMODIALYSIS MACHINES

There are several common types of hemodialysis machines. The most commonly used are *coil dialyzers*, *parallel flow dialyzers*, and *capillary kidneys*.

Coil dialyzers contain long flattened cellophane tubes coiled about a central core. A typical coil dialyzer is shown in Figure 10. The individual loops of the coil are separated by layers of plastic screening in order to allow the greatest possible exposure of the membrane to the surrounding dialysate.

Parallel flow dialyzers, like the one shown in Figure 11 consist of sandwich-like layers of flat sheets of membrane that allow blood

to flow through the central layer and dialysate to flow on either side of the membrane containing the blood. The blood flows between the layers, and the dialysate flows outside the layers, usually in opposite directions.

Capillary kidneys consist of thousands of tiny plastic tubes lying parallel to each other in a clear plastic cartridge. The blood is passed through the inside of the tubes, and the dialysate is circulated around the outside of the tubes.

Some dialyzers have a special compartment containing chemical compounds that will absorb waste products. This reduces the total amount of dialysate required in each hemodialysis treatment.

DIALYSATE SYSTEMS

The hemodialysis machine is attached both to the patient's bloodstream and to a machine called a *dialysate supply system*, which prepares and delivers the dialysate to the hemodialysis machine.

Figure 10. Coil dialyzer



A large number of systems to provide dialysate solution are now available, but there are two basic types: the batch system and the proportioning system.

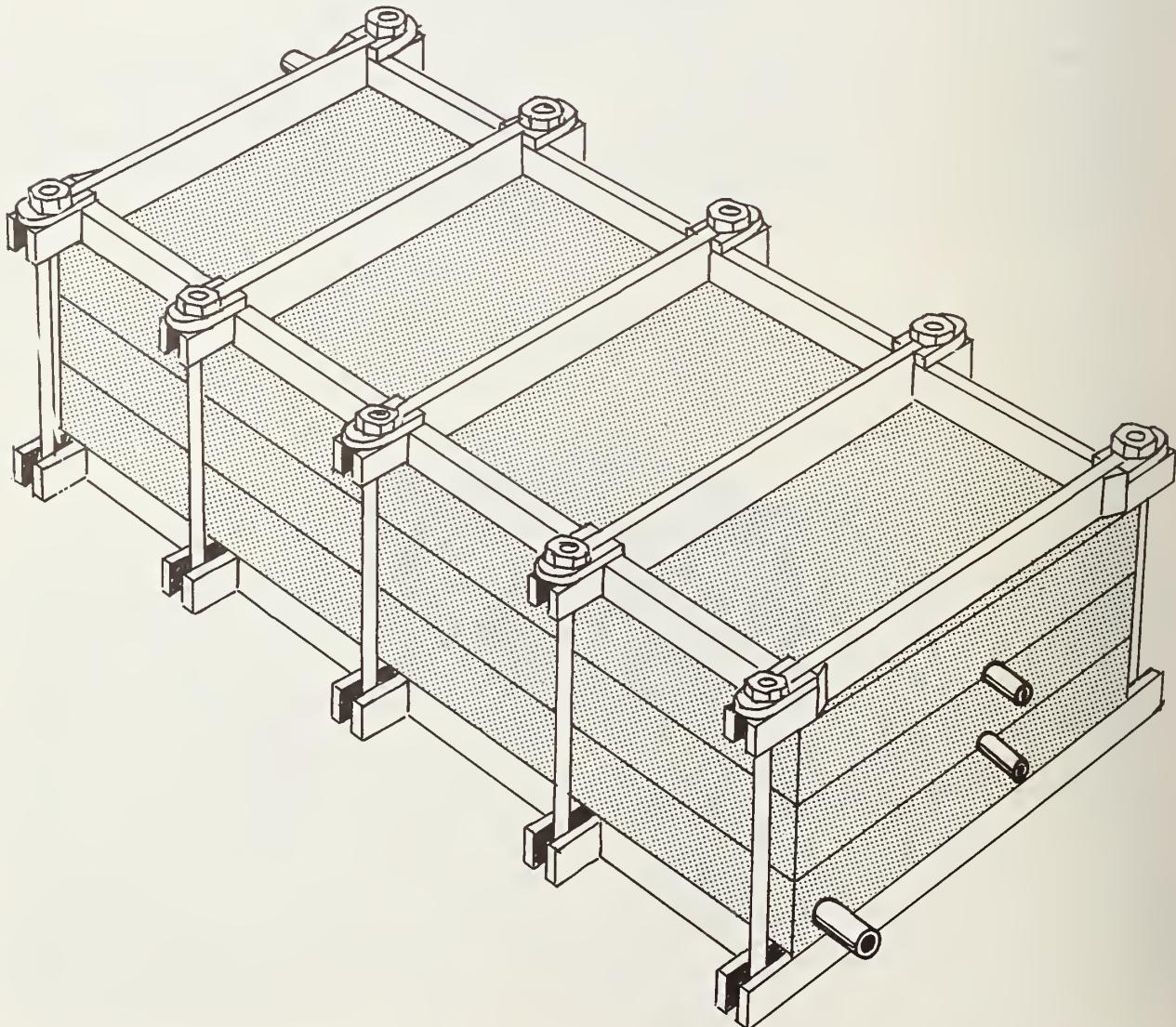
Batch system. This type of equipment involves the preparation of a large amount (approximately 100 to 120 quarts) of dialysate by mixing the concentrated commercially prepared chemicals with large amounts of purified water. The advantage of the batch system is the simplicity of its mechanical

operation. The main disadvantage is the presence of large amounts of dialysate, which requires a large amount of space.

Proportioning Systems. This type of equipment is designed so that continuous automatic mixing of concentrated chemicals with purified water goes on during a treatment.

The advantage of proportioning systems is the smaller space required, but a possible disadvantage is the possibility of error in mixing. For this reason, many monitoring

Figure 11. Parallel flow dialyzer



devices and safety alarms to indicate a chemical imbalance in the dialysate are built into the equipment.

PERITONEAL DIALYSIS

Another method of removing waste from the body is peritoneal dialysis. The peritoneum, a membrane surrounding the intestine and other organs in the abdominal cavity, has physical properties similar to those of cellophane and can function like the cellophane membrane in the hemodialysis machine. Many small blood vessels line the peritoneal membrane. When the dialysate is introduced slowly into the abdomen, it bathes the peritoneal membrane. This allows metabolic endproducts to leave the bloodstream by diffusion and excess water to leave by osmosis and enter the dialysate solution in the abdomen. Repeated cycles of infusion and drainage are carried out, thereby reducing the concentration of metabolic endproducts and excess water in the body. Your physician may recommend peritoneal dialysis as the most appropriate form of dialysis treatment for you.

Several techniques of peritoneal dialysis have been devised to minimize your discomfort and allow fluid to flow safely into your abdomen. These techniques vary from one medical center to another. In some cases, a disposable catheter is inserted in the abdomen with each dialysis treatment. In other cases, a permanent catheter is inserted.

The frequency of peritoneal dialysis depends upon the medical need for this treatment. A peritoneal dialysis treatment may last from eight to forty-eight hours, once every three to fourteen days. Some patients perform peritoneal dialysis treatments at home, dialyzing themselves for 12-hour periods, three times a week. This can be done by the patient without assistance. A specifically tailored schedule of dialysis will be worked out for every patient with the aim of trying to restore him or her to the best state of health with a minimum amount of time spent in peritoneal dialysis.

MEDICATIONS DURING DIALYSIS

Medications called *anticoagulants* are required during hemodialysis to prevent blood

clotting. If clots form, the artificial kidney and blood lines could become completely blocked. This problem is prevented by the use of drugs called anticoagulants; heparin is a commonly used anticoagulant.

Most patients can tolerate anticoagulants without problems. However, in cases where patients have abnormal bleeding or a tendency towards abnormal bleeding, the patient must receive *regional heparinization*. The term "regional" is used to indicate that heparin is added to the blood as it leaves the body, but the heparin is neutralized by injecting a neutralizing agent called protamine into the blood before it returns to the body. In this way, blood entering the dialysis machine will be anticoagulated. Blood returning to the body will clot normally.

During dialysis, this process requires a continuous infusion of heparin into the artery and a continuous infusion of protamine into the vein. Special infusion pumps are used to control this complex type of treatment.

Occasionally, another type of anticoagulant, Coumadin, is taken by mouth each day to prevent clots from forming in the shunt or fistula between dialysis treatments. This will tend to reduce the amount of heparin needed during dialysis, but heparin is still necessary.

THE DIALYSIS SITE

There are three general situations in which dialysis can be performed. These are inpatient dialysis, outpatient dialysis, and home dialysis.

Inpatient Dialysis

Inpatient dialysis is performed on hospitalized patients, either because they are too ill at the beginning of the dialysis treatment program to be treated as outpatients or because some medical complication or necessary surgical services require inpatient stay.

Outpatient Dialysis

Outpatient dialysis can be performed in a variety of settings. Hospital-based outpatient dialysis is performed in a hospital for patients who do not stay overnight at the hospital.

Limited care dialysis is performed in a unit where patients who are not trained in the technique of dialysis are provided treatment by a trained professional staff. Limited care facilities can be, but usually are not located in a hospital. Self-care dialysis is performed in a unit where a trained patient can dialyze himself with help from a family member or friend, and with little or no professional supervision. Many dialysis centers offer day and night shifts, both for the convenience of patients and in the interest of economy.

Home dialysis. You can be trained to perform hemodialysis at home with the help of a member of your family. Training in home dialysis is offered by many medical centers in a four to six week course. Home hemodialysis is less expensive than having dialysis in a center, and also saves the patient travel time. Many patients on home hemodialysis have said that they enjoy spending more time with their families, and have a greater sense of independence and more flexibility in scheduling treatments than they would if they had hemodialysis at a center.

Since one of the goals of treatment for end-stage renal disease is to help you return to as normal a lifestyle of work and recreation as possible, home dialysis is considered an excellent method of treatment. This decision has to be made carefully, and with the complete understanding of the family member or friend who would be helping you with home dialysis.

Some patients choose not to perform dialysis at home because of the emotional stress, the lack of someone to help, the lack of space or facilities, or because they have an unstable medical condition. Talk to your doctor about your needs and your resources, and think carefully about all methods of dialysis available to you. It is your treatment, and you should help decide where you will be treated. You may worry that home treatment will be inferior to treatment in a center. However, most patients on home dialysis do as well as or better than patients in centers. Though performing dialysis will probably be a new

and worrisome experience for you in the beginning, good training and proper understanding of the method will give you the necessary confidence.

Finally, requiring hemodialysis does not mean that you cannot travel. There are hemodialysis centers throughout the country, and it is possible to arrange in advance for hemodialysis treatments in other cities if you decide to travel. Your doctor can help you make these arrangements.

POSSIBLE PROCEDURAL PROBLEMS OF HEMODIALYSIS

You should be aware of some problems that can occur during hemodialysis, and what can be done to prevent and solve them. An important part of your training will be learning what signs and symptoms you should look for during dialysis to help prevent serious trouble from developing, and what to do if anything goes wrong during the procedure. Some of these problems will need attention from your physician or his staff, even if you are doing home dialysis.

Blood Leaks. Occasionally, the membrane of the hemodialysis machine develops a small leak or, rarely, a larger break or rupture, allowing blood to leak from the blood compartment into the dialysate. Blood leaks are easily detected. In general, these problems represent more of a nuisance rather than a threat to you. There are a variety of monitors that can detect minute amounts of blood in the dialysate. Should leakage occur, the dialysis itself need not be discontinued. By temporarily closing off the tubes connecting the patient to the artificial kidney, the person conducting the dialysis can replace the dialyzer membrane in a matter of minutes.

Another kind of blood leak can occur in the tubes carrying blood between the patient and the dialyzer. This can result in rapid and severe bleeding and requires immediate correction. A variety of pressure monitors and alarms are available so that a leak can be detected quickly.

Hypotension. This term refers to abnormally low blood pressure. This may result from the blood leakage described previously or, more commonly, from reduction of the pa-

tient's blood volume through excessive fluid removal during dialysis. In cases of hypotension the patient feels faint and the situation can be quickly corrected by the addition of a salt solution (saline) to the bloodstream while lowering the dialysis flow rate. Patients who are accustomed to hemodialysis rapidly become acquainted with the symptoms that indicate the earliest signs of hypotension and can administer a saline solution before hypotension progresses.

Incorrect Dialysate Concentration. The person mixing the concentrated chemicals with water in the batch system should do so carefully. The wrong concentration of chemicals in the dialysate may cause immediate side effects such as vomiting and generalized muscle aching. To avoid this problem, the person performing dialysis must always have check-points at which to monitor the concentration of the dialysate. Most equipment has special safety monitors to alert you if this problem occurs.

Infection. Infection resulting from dialysis usually can be avoided by using sterile technique, which means proper cleaning of the skin or external shunt, and applying antiseptic to any point of needle entry or opening of the blood lines. If harmful bacteria, viruses, or fungi enter the bloodstream, they can cause high fever and possibly infection in various parts of the body. This complication is usually detected within two to six hours after the treatment begins, because the patient's temperature will rise and there may be chills, pain, or aching muscles.

MEDICAL PROBLEMS ASSOCIATED WITH DIALYSIS

Dialysis can correct many of the physical problems of uremia, such as the symptoms due to accumulation of metabolic endproducts in the blood and other body fluids. As one remains on dialysis for months to years, however, certain other consequences of end-stage renal disease may develop. Individuals vary greatly as to the severity and time at which problems occur. It is your physician's job to monitor your physical condition, laboratory data, and dialysis records to determine if you have complications. Some long-

term complications can be treated with additional medications or with changes in your dialysis program. Others are more difficult to treat and may be resolved only by surgery or transplantation. Some of the more common long-term problems are listed below.

Fluid Overload

One important function of the kidney is to remove excess salt and water from the body. Normally, salt and water (along with metabolic endproducts) are eliminated from the body in the urine. Salt and water enter the body primarily by dietary intake. In end stage renal disease, quite frequently little or no urine is made by the kidney. Therefore, any salt and water entering the body through dietary intake will remain in the body until they are removed by dialysis. If too much salt and water enter the body between dialysis procedures, a condition known as *fluid overload* occurs. When this happens, there is weight gain and eventually certain symptoms begin to appear. These include shortness of breath, difficulty breathing either with exertion, or while lying flat, and swelling of the ankles. All of these symptoms result because your heart is presented with more blood than it is capable of pumping. Serious medical consequences can result if fluid overload is not corrected. The easiest way to deal with this problem is to *avoid it*. To prevent this condition, restriction of salt and water in your diet is essential. Fluid overload does not occur in patients who carefully watch their diet.

If this condition does occur, it can be treated medically in several ways: First, you *must* restrict your dietary salt and water intake. Next, fluid removal through either longer or more efficient dialysis is necessary until your excess weight has been removed. In addition, your blood pressure will need careful monitoring and if it remains elevated, it may need lowering with medication. Finally, certain medications such as digoxin or digitoxin, may be necessary to increase the efficiency of your heart's pumping. In summary, the best way to handle this problem is not to get it. Careful watching of your dietary intake will eliminate complications of fluid overload.

Hyperkalemia. Potassium, like salt and water, is another element which builds up in your body when your kidneys do not function properly. High blood potassium level (hyperkalemia) is perhaps the single most serious complication for patients on hemodialysis. Since potassium also enters the body through the foods you eat, its buildup in the body and bloodstream can be prevented by carefully avoiding certain foods (such as fresh fruits and fruit juices) which are very rich in potassium. Unlike the problem of fluid overload, there are very few symptoms produced by hyperkalemia.

When they appear, however, they can be life threatening. Among these symptoms are an irregular heart beat and generalized muscular weakness. Often, *potentially fatal* levels of potassium in the blood can be reached without any warning and without any symptoms. Very high blood potassium levels require emergency medical care (including dialysis), and may require hospitalization. To be certain that this condition will not develop, you must first understand your diet. Your doctor and dietician will instruct you carefully about potassium and your diet and if you follow their instructions, you will prevent complications and maintain your health.

Hypertension. This term means high blood pressure and does not refer to nervousness or being hyperactive or tense. Most patients with end-stage renal disease have some degree of hypertension. In some instances, hypertension itself may have caused the kidney failure. In other cases, hypertension may have resulted from damaged kidneys and the resulting release of certain hormones into the bloodstream. Before dialysis is started, medications are required to reduce the blood pressure to normal. There is a wide variety of medications that are helpful, although each has side effects. Your physician will choose the medications best suited to your particular condition. Once a patient has begun hemodialysis, blood pressure usually is lowered to some degree by removal of excess fluid from the body. However, this may not be enough to restore blood pressure to normal, and additional medications may still be required.

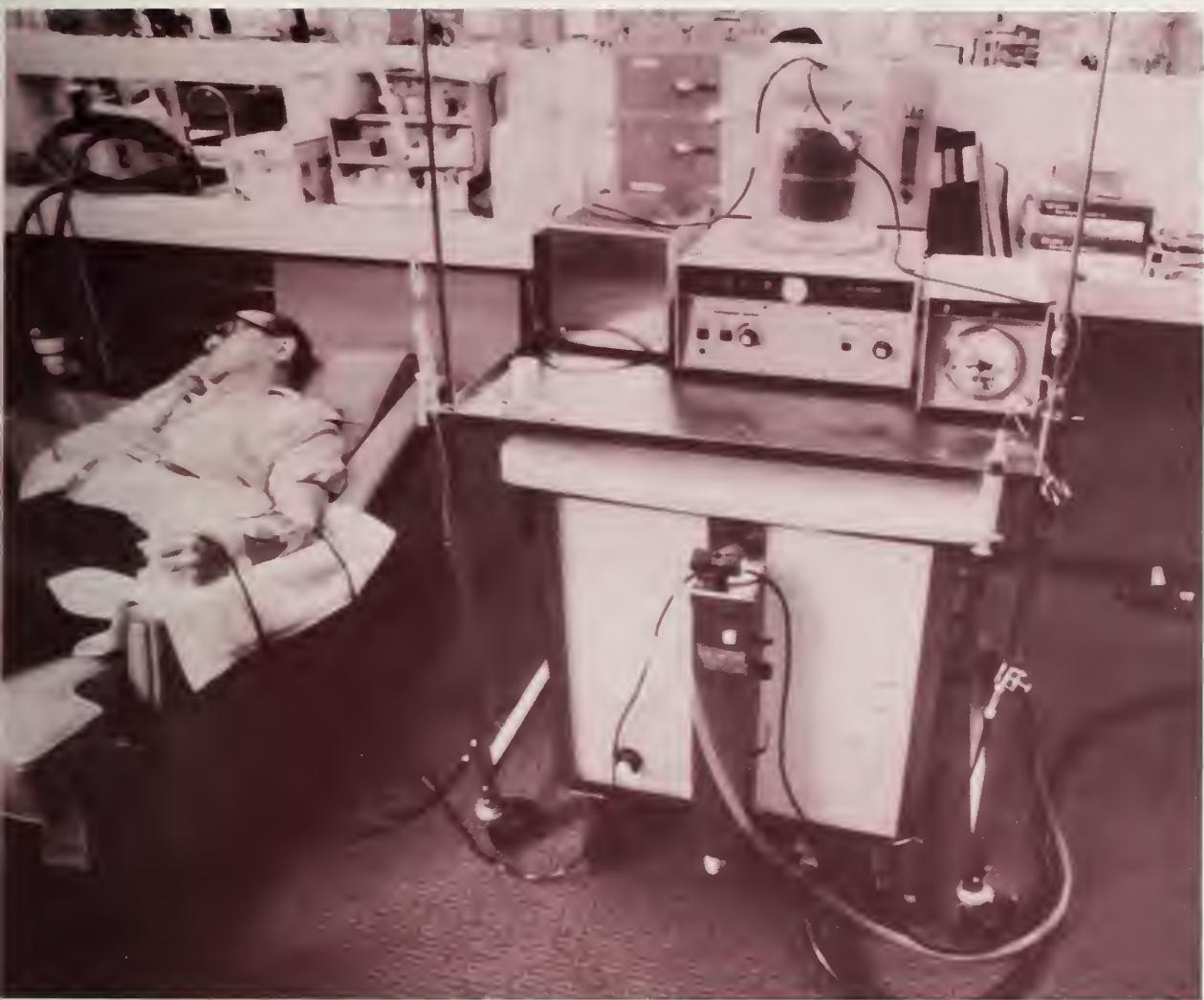
Anemia

The term anemia refers to a low red blood cell "concentration" in your blood and occurs as a direct result of end stage renal disease. In most patients this condition can be treated with a variety of medications and without frequent blood transfusions. These medications commonly include a vitamin called folic acid, iron, and occasionally other vitamins and hormones. Generally, it is preferred to treat anemia with medication since transfusions may have undesirable side effects which include infections and fever. Also, a blood transfusion does not cure the problem of anemia but only serves as a temporary measure for raising the red blood cell count (hematocrit). The medications, on the other hand, have few serious side effects and may raise the red blood cell count on a more permanent basis without the risk of undesired complications. This is especially important in patients awaiting a kidney transplant. Frequent transfusions may result in the production of certain antibodies in the body which may play an important role in the rejection of a transplanted kidney.

Although most patients with end-stage renal disease have some degree of anemia, the body adapts remarkably well. The main symptom of anemia is a greater tendency toward fatigue.

Neuropathy

For reasons that are not fully understood, some patients with end-stage renal disease experience a change in nerve function, usually in the feet and legs or hands and arms. Symptoms of this problem are numbness and tingling, or muscular weakness. Neuropathy results in decreased sensitivity to temperature extremes and to pain. The condition is often more severe in diabetic patients, because diabetes also causes nerve injury. At present, there are no medications that can reverse this process. Some physicians believe that neuropathy can be prevented by starting dialysis earlier, or, if it has already developed, that it can be improved by increasing the number of hours of dialysis each week. A kidney transplant is the most successful method of correcting this



Patient on hemodialysis

problem, but this is not possible for all patients.

Bone Disease. Bone disease is a medical problem affecting all patients with end-stage renal disease to some extent. With good medical care and patient cooperation, however, the complications of this problem can be minimized. If this problem is not carefully managed, such complications as progressive thinning of bones and bone fractures can result. To help avoid these complications, several treatment methods are necessary: First, antacids containing aluminum hydroxide gel (such as Amphogel or Basagel) may be necessary to maintain the proper

ratio of phosphorous and calcium in the blood. This is essential to prevent bone thinning and ultimately the fractures that might result from structurally weakened bone. Next, the use of dialysates containing a high concentration of calcium, oral calcium supplements and occasionally vitamin D supplements may help to increase the amount of calcium absorbed by the body. The calcium will then be deposited in the bones to give them greater strength.

Rarely, a patient with end stage renal disease will develop enlargement of certain glands located in the neck known as the parathyroid glands. Enlarged parathyroid

glands primarily result from a long standing imbalance between the ratio of calcium and phosphorus in the blood. Patients who do not follow their antacid regimen over a long period of time or have developed end stage renal disease over a long period of time without seeking medical advice are the most likely patients to develop parathyroid enlargement in addition to bone disease. Occasionally, the enlarged gland(s) will need surgical removal.

To summarize, strict adherence to your antacids and other medications is necessary to minimize your chances of developing serious bone or parathyroid disease.

WHILE YOU ARE ON DIALYSIS

Although hemodialysis is not painful, some patients find that it can be uncomfortable. The hemodialysis procedure causes chemical changes in your body that in turn can cause headaches, and, occasionally, leg cramps. However, most patients are comfortable enough to read, sleep, or have visits with friends while having hemodialysis.

The dialysis procedure should not affect your sight, hearing, or other senses. Although your strength and endurance will probably be lessened, there are still many activities you can do. Your doctor will give you guidelines as to your level of activity.

You will have to make the care of your health a way of life. For instance, you will be on a carefully prescribed diet; your activity will be regulated; and you must not miss any hemodialysis sessions. However, it is most important that you attempt to continue having an enjoyable, productive life. Adapting to hemodialysis means making the treatments a part of your life, but not the center of your life. When you learn to accept the role that hemodialysis plays in your life, you will find your treatments easier and your life more enjoyable.

COMMONLY ASKED QUESTIONS

QUESTION: How long can a person live on hemodialysis?

ANSWER: This question is difficult to answer because of the variation among individuals. However, within a large group of dialysis patients, approximately 90 to 95 percent will live for one year or longer. Consult your doctor and treatment team regarding survival data and ways to help improve your outlook. Patients with other illnesses complicating their kidney disease, such as heart disease, diabetes, cancer, or lupus erythematosus, have a much more complicated and unpredictable course.

QUESTION: Will the artificial kidney help my kidneys heal so eventually I won't need dialysis?

ANSWER: No. The artificial kidney substitutes for normal kidneys by removing waste products and fluid, but it has no healing effect on the kidneys. Some patients with acute kidney failure due to shock, poisoning, or infection regain kidney function after several days or weeks. But the use of the artificial kidney does not directly affect the healing process. In this situation, dialysis sustains life until the patient's kidneys recover from the acute kidney failure. However, patients with chronic and slowly progressive kidney failure require dialysis for the rest of their lives, or a kidney transplant. Since each patient's case is unique, you should discuss your condition with your physician.

QUESTION: Will I need dialysis more often if my kidneys are removed?

ANSWER: In some cases there may be a slightly increased need for dialysis, but this varies with different patients.

QUESTION: Is one type of dialysis equipment better than any other?

ANSWER: All types of equipment are designed to do essentially the same job. Your physician will be able to recommend the equipment best suited to your particular needs and circumstances.

QUESTION: Is peritoneal dialysis as efficient in removing wastes from my body as hemodialysis?

ANSWER: Peritoneal dialysis is about 1/6 as efficient as hemodialysis. That is why peritoneal dialysis requires longer treatment sessions.

QUESTION: Are there advantages to peritoneal dialysis over dialysis with a hemodialysis machine?

ANSWER: Yes, in some cases. Some patients with severe heart disease are unable to tolerate treatment with the hemodialysis machine because their hearts cannot tolerate the work load of pumping blood outside the body and through the kidney machine. Peritoneal dialysis is preferred for other patients with diseased arteries because they cannot tolerate the shunt or fistula. Technical difficulties may make the use of an artificial kidney impractical for small children. Also, some patients prefer peritoneal dialysis. Some find it more convenient, and others feel better on this form of therapy.

QUESTION: Will I be treated by both peritoneal dialysis and hemodialysis?

ANSWER: Perhaps. You may find that you will require several peritoneal dialysis treatments before having shunt or fistula surgery and until the blood vessels of your fistula are ready for use with the artificial kidney. Some patients may remain on peritoneal dialysis indefinitely.

QUESTION: Will I be able to choose when and where I will have my dialysis treatments?

ANSWER: Unless you have an unusual health problem, you will be able to have a friend or family member help you perform dialysis at home, or you may be treated in a treatment center near your home. Depending upon the treatment center's schedule, you will have hemodialysis treatments at times that best fit your daily schedule.

QUESTION: Do all centers offer home hemodialysis training?

ANSWER: No. Some patients must receive home hemodialysis training at a center far from their homes. Total training time may range from four to six weeks.

Kidney Transplantation

ANOTHER MAJOR TREATMENT for end-stage renal disease is kidney transplantation. This involves removing a kidney from a living relative of the patient, or from an unrelated person who has died, and surgically placing the new kidney into the patient. The goal of kidney transplantation is to replace the diseased kidneys with a well functioning kidney. The advantages of transplantation may make it the most desirable form of treatment for many patients with end-stage renal disease. Persons who are good candidates for transplantation and who have successful transplants are relieved of the burden of frequent dialysis treatments and have fewer expenses than they otherwise would with a dialysis program. Successful transplantation can give the patient greater energy and vitality and a less restricted diet than if he were on dialysis.

If you receive a kidney transplant, you will have to take medication for the rest of your life to prevent rejection of the transplanted kidney. The medications used to prevent rejection may also cause complications. Talk with your doctor, who can arrange for you to meet with a member of the transplantation team. In this way the advantages and disadvantages of both transplantation and hemodialysis can be fully explained. Make sure you have all the information available to you, and decide with the advice of your physician which form of therapy is best for you.

About 65 percent of kidneys donated for transplant come from cadavers (persons who have recently died) and 35 percent from living relatives of the kidney patient. Relatives who are considered as potential kidney donors undergo complete physical examinations and various laboratory tests, including a thorough evaluation of their kidneys. Because the medical requirements for living donors are strict, the surgical risk is low. Among the more than 5,000 people who

have donated kidneys, serious complications have been extremely rare.

Living related donors usually have a medical evaluation lasting three to five days before donating a kidney. They are hospitalized for ten to fourteen days after the surgery when the kidney is removed. The time lost from work after surgery is usually six to eight weeks. The reserve power of kidneys is tremendous, and when one normal kidney is removed, the remaining normal kidney enlarges and increases in function by approximately 50 percent. This means that the remaining kidney functions at approximately 75 percent of both kidneys before donation. This amount of function is more than adequate to maintain a donor in a healthy state.

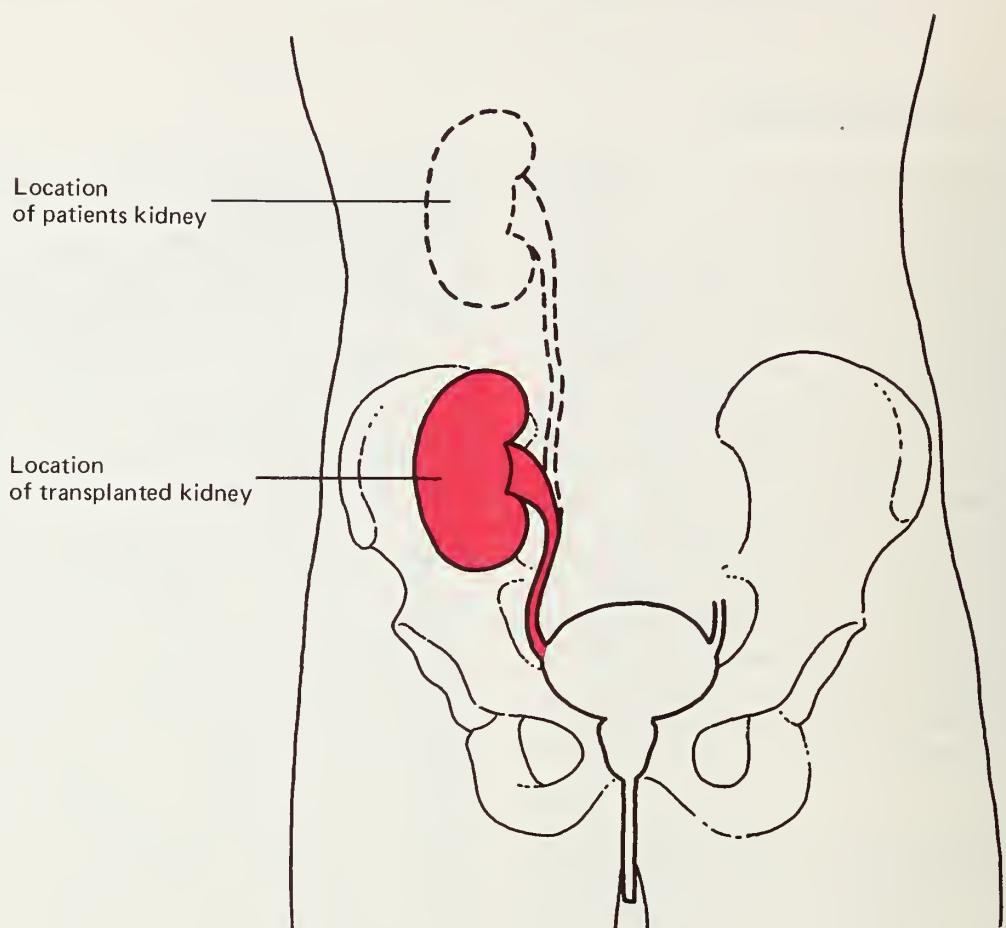
Most forms of kidney disease affect both kidneys at the same rate. Therefore, if a donor is unfortunate enough to develop kidney disease at any time after donating a kidney, he would be unlikely to develop end-stage renal disease much earlier than if he had two kidneys. However, the person with only one kidney runs a slightly increased risk of kidney failure from such occurrences as injury, tumors and blood vessel disease.

The life expectancy of a person who has had one normal kidney removed is no different from that of a person with two kidneys. The quality of life is unchanged and there are no restrictions of any kind after recovery from surgery. Women who have donated a normal kidney do not experience any special risk in pregnancy or childbirth.

If a relative expresses interest in donating a kidney or wants additional information about your transplant, he or she can consult with the physicians, social worker, psychiatrist, and, if possible, a previous kidney donor.

A donor's kidney tissue must be similar to yours in order to reduce the chances of your body's rejecting the transplant kidney. Before a kidney transplant is performed, tis-

Figure 12: Location of kidney before and after transplant



sue-typing is done on both the kidney donor and the recipient. Tissue-typing involves doing a number of blood tests, in order to estimate the chances of the kidney's being accepted or rejected. Kidneys can be preserved outside the body for up to 48 hours, which provides time for doing the tissue-typing and, if necessary, for transporting the kidney to the patient with the most compatible match.

THE TRANSPLANT OPERATION

In some patients who are considered candidates for kidney transplantation, it becomes necessary to remove the patient's own diseased kidneys. The most common reasons for recommending this surgery are the presence

of chronic infection in the patient's own kidneys and uncontrolled hypertension (high blood pressure).

Kidney transplants are placed in the pelvis rather than in the usual kidney location in the side. The locations of natural kidneys and a transplanted kidney are shown in Figure 12. The artery that carries blood to the kidney and the vein that removes blood from the kidney are surgically connected into two blood vessels already existing in the pelvis. The ureter, the tube that carries urine from kidney to bladder, is also transplanted. The transplanted ureter is usually connected to the patient's bladder, although occasionally it is attached to the patient's ureter.

The surgical risks for any patient with

end-stage renal disease are greater than those of patients with normal kidney function. Nevertheless, the patient survival rate from transplant surgery is greater than 98 percent.

PROBLEMS ENCOUNTERED IN KIDNEY TRANSPLANTS

Your body has a defense system that involves the recognition and destruction of foreign bodies. This is what makes resistance to infection possible. When harmful bacteria and other substances enter the body, certain tissues in the body produce proteins called *antibodies* that help destroy the foreign matter. Your body will attempt to treat a transplanted kidney the same way. (A transplanted organ is sometimes referred to as a "graft" or a "transplant.") The primary problem of managing the health of someone with a transplant is to control the part of the immune system that rejects the graft. This must be accomplished without destroying the part of the immune system that fights infections from bacteria, viruses, fungi, and other organisms.

Rejections may be classified roughly into three general types: *hyperacute rejection*, *acute rejection*, and *chronic rejection*.

Hyperacute Rejection. Fortunately, this form of rejection is rare, for it occurs within minutes or hours after transplantation. It results in immediate, irreversible destruction of the graft because the recipient's body immediately recognizes the graft as foreign. There is no known treatment for this form of rejection. Another form of rejection called "accelerated rejection" is recognized by many experts. This refers to rejection within two to eight days after the operation.

Acute Rejection. This is rejection of the transplanted kidney sometime after recovery from the operation. Acute rejection is the most common form of rejection, and usually is the form of rejection accounting for most cases of rejection that are difficult to diagnose. At least 50 percent of recipients of cadaver transplants undergo one episode of acute rejection, but prompt treatment con-

trols or reverses the rejection in about 75 percent of the cases. Although acute rejection is most frequent during the first three months after transplantation, it may occur after many months or years. This is why anti-rejection therapy with certain medications must be continued indefinitely and why followup laboratory studies of kidney function are essential.

Frequently, acute rejection is detected by laboratory tests before symptoms occur. With more sudden or severe episodes of acute rejection, there may be fever, generalized aching similar to that experienced during an attack of the flu, sudden weight gain with or without edema (swelling due to fluid retention), unexplained decrease in the amount of urine produced, and tenderness over the graft. Any of these symptoms or signs means that the transplant patient should contact his doctor immediately.

Treatment of acute rejection varies, depending upon individual circumstances. Some mild episodes of rejection may be controlled on an outpatient basis, while more severe rejections require hospitalization and close observation.

Chronic Rejection. This is a continuous tendency to reject the graft, which must be carefully controlled. Chronic rejection does not occur in many patients, though it is often seen in patients who have had several episodes of acute rejection. There usually are few signs or symptoms of chronic rejections, other than a tendency toward edema and weight gain. Therefore, chronic rejection is usually diagnosed by repeated laboratory tests of kidney function. With careful medical treatment, the rejection process can be halted so that transplant function may be extended for months or years. Patients suffering from chronic rejection usually can lead relatively normal lives, though they may need followup visits more frequently than other patients. As rejection progresses and kidney function diminishes, it becomes necessary to readjust doses of medications and begin dietary restrictions similar to those required when the patient's own kidneys were failing.

Prevention and Treatment of Rejection

Two medications have proven successful in the prevention and treatment of rejection. These are azathioprine (Imuran) and corticosteroids. Azathioprine is a powerful medication that can help prevent rejection of a graft. Given in too large a dose, azathioprine also inhibits other functions of the body's defense system, making patients more susceptible to infection by viruses, bacteria, and fungi. A small percentage of patients may develop liver damage. Frequent tests of the blood, urine, and sputum are required to monitor the action of this medicine in order to prevent undesired effects. Corticosteroids are medications with dramatic effects in helping prevent rejection. These medications are given in increased amounts during periods of threatened rejection. These large doses tend to cause multiple side effects and complications including facial fullness, rapid weight gain, acne, increased susceptibility to infection, and some harmful effects on the skeletal system. Your doctor will carefully select the type of corticosteroid and the dosage he believes is most effective and safe for you.

An important part of your postoperative care will be learning about the different medications and their dosages. You will be given the primary responsibility for your medications under the close direction of your physicians. You should carry with you at all times information on the medications you are taking. This should include both the name and the dosage of your medications. Having this information with you will help if you are involved in an emergency or if you need to see a doctor other than your kidney specialist for any reason. Your kidney specialist will give you this information in writing if you wish.

Irreversible Rejection, Dialysis, and Retransplantation

Irreversible rejection is managed by stopping antirejection medication, and in most instances, the transplanted kidney must be removed surgically. The patient is then returned to chronic hemodialysis and, following full surgical recovery, may be considered

a candidate for a second transplant. The results of second transplants are not quite as good as those with first transplants, but are almost as successful.

The Risk of Infection

The use of medications to prevent rejection of the transplanted kidney lowers your resistance to infection. In the event a serious infection occurs, it is likely that the dosages of azathioprine and corticosteroids will have to be reduced. If rejection threatens simultaneously, it is frequently wiser to remove the kidney transplant than to continue antirejection therapy, which can very seriously endanger your health by allowing infection to spread. Your doctor can treat many infections and cure most of them with the prompt and proper use of antibiotics. However, early and vigorous treatment is necessary, making it important for you to notify your doctor of any fever or other symptoms of illness you have. Be sure to keep appointments for followup visits so that serious infections can be detected as early as possible.

COMMONLY ASKED QUESTIONS

QUESTION: Is the success of transplantation directly related to the tissue-typing match?

ANSWER: In the case of family donors, the answer is yes, but tissue-typing is a less significant factor with cadaver donor kidneys. Some poor matches with cadaver kidneys are not rejected, and some good matches are rejected. Perfectly matched family donor transplants do better than cadaver kidneys.

QUESTION: Is there an age limit for people who want to have transplantation

ANSWER: No. Medical suitability for transplantation is based upon an individual's overall health, particularly the condition of the blood vessels and the heart. However, people older than fifty to fifty-five years of age generally have more problems due to the condition of the blood vessels, and success of the transplant is much more difficult to predict.

QUESTION: Can a diabetic receive a kidney transplant?

ANSWER: Yes, although the complications of surgery itself, including infection, may be greater. Diabetic patients tend to have a higher incidence of blood vessel disease, making the chances of success for both dialysis and transplantation lower than for nondiabetic people. Also, control of diabetes is more difficult in transplant patients since corticosteroids may raise the level of blood sugar.

QUESTION: If my kidneys were destroyed by diabetes, high blood pressure, or glomerulonephritis, is there any chance that the same disease would destroy my transplant?

ANSWER: There is a small chance that the original disease affecting your kidneys may also destroy transplant function. In a practical sense, certain forms of glomerulonephritis are the only major types of kidney disease that recur suddenly. In the other instances where the disease does recur, the process of recurring is slow and may not affect the transplant for several years, making the transplant very worthwhile.

QUESTION: Can a kidney from a person

of one race or sex be transplanted into a person of another race or sex?

ANSWER: Yes, providing blood type is compatible and there are no major problems with tissue-typing.

QUESTION: What is happening while I am on the "waiting list"?

ANSWER: Although organ procurement systems may differ slightly, they are carefully monitored for fairness and efficiency. Each time a kidney of your blood type is available, your serum will be tested with that of the potential donor (testing for reaction of your cells against those of the donor). When a kidney with a good match becomes available and your physician feels that the kidney would have an optimal chance of success, he will notify you and make preparations for the transplant.

QUESTION: Will my transplant function immediately?

ANSWER: There is a chance that your new kidney may not function immediately due to a process called acute tubular necrosis (ATN) which is not a form of rejection. If this occurs, your physician will explain the process to you, and you may need intermittent hemodialysis until the kidney begins to function.

Treatment Alternatives

YOUR PHYSICIAN and other health professionals will give you a complete explanation of all available treatments for end-stage renal disease. They will give you information about the risks and benefits of different treatment methods. The choice of the best method of therapy can be made only when full information is available to you. Specific information about your case can best be given to you by your kidney specialist.

All treatment will require your consent or that of your parent or legal guardian. This includes your right to withdraw from therapy at any time. It is your physician's obligation to recommend any change in therapy that he considers medically advisable, including your consulting other physicians. But ultimately any decision involving a major change in treatment rests with you. Once all important information has been made available to you, it is your responsibility to participate actively in decisions that are made and to cooperate fully with your physicians and other health professionals.

An informed patient is better equipped to cope with the stresses and decisions that may arise during dialysis. As a patient with end-stage renal disease, you should know the answers to the questions in the following list. Your doctor or members of his or her staff will discuss these questions with you and answer any additional questions you may have.

GENERAL QUESTIONS

- What is the diagnosis of my kidney problem? You will be given both the medical name of your disease and a description of the disease in terms you can understand. For some patients with end-stage renal disease, a specific diagnosis may not yet be established because of limited information.
- In addition to kidney disease, do I have any other significant illness? How do other illnesses relate to my kidney disease?

- What choices of treatment do I have?
- How will I participate in the decision about the type of treatment I will receive? Should I be treated at a dialysis center or at home? What kinds of treatment may I choose from (hemodialysis, peritoneal dialysis, transplantation)? Am I a suitable candidate for kidney transplantation? If not, why?
- How much will my care cost?
- Will medical help be available regardless of my financial difficulties?
- Do I have a complete enough understanding of my condition and the treatment alternatives to decide whether I want a kidney transplant?
- Does my family fully understand my condition?
- Do I feel comfortable talking with my doctor? If not, have I advised him of all difficulties I am experiencing?
- Will I be asked to participate in research studies, and if so, will I be fully informed regarding the nature of the research?

SPECIFIC QUESTIONS RELATED TO DIALYSIS

- Will I be able to choose between peritoneal dialysis and hemodialysis?
- Where will the dialysis be done—at a dialysis center, limited care facility, or home? Will I participate in the choice of location?
- Where will I get dialysis equipment and supplies? How will they be delivered? How much will it cost? How will it be paid for?
- Will I be able to select a shunt or a fistula?
- How will I participate in my care? Should I expect doctors, nurses, and technicians to perform all procedures? Should I be participating in my care? If so, to what extent?
- Will I understand, in specific terms, my

doctor's treatment goals for me (ideal weight, blood pressure, hematocrit, blood chemistries, medications, diet, and fluid intake)?

SPECIFIC QUESTIONS RELATED TO TRANSPLANTATION

- If I need a transplant, where can I get a kidney?
- Do I have a choice between a living relat-

ed donor transplant and a cadaver transplant at the transplant center?

- Do I have a living blood relative willing to donate a kidney? What are the risks to the living donor?
- What is the relationship of my treatment facility to existing transplant centers? Can I choose the center for my transplant?
- Will I be told the success rate of living donor and cadaver transplant results in cases similar to mine?
- What is the value of tissue-typing?

End-stage Renal Disease In Children

THE PARENTS OF CHILDREN who have kidney failure face special problems.

End-stage renal disease will cause a disruption in a child's life that he or she is usually not prepared to handle without a great deal of parental help and support. Though your child will have much to do for himself, you may find him more dependent on you for guidance than ever before. Your child may not recognize this increased dependence, because children tend not to acknowledge the seriousness of the condition. You and your child must learn to work together through the course of hemodialysis or kidney transplant; you must become a team, mutually dependent and mutually supportive.

REHABILITATION

One of the main goals of rehabilitation is to have the child participate in education. The child is not considered rehabilitated unless he is continuing his education. You should keep close contacts with your child's teachers to help your child do all he can in school. Explain your child's limitations on activity to the teacher and ask the teacher to help you monitor your child's development. The school nurse or guidance counselors may be able to help you if your child shows problems in adjusting to school.

It will help your child if you can be open and honest about kidney failure. Do not make a secret of any part of the therapy. Be frank about the condition and the treatment, and help your child to do the same. Reassure your child that there is nothing to hide. For instance, if you feel it would help, you can post a list of the foods your child should not eat in the kitchen. Help your child to accept himself as he is in order to reduce the problems caused by feeling different from other children.

Family relationships can be seriously upset

by dialysis therapy. Dialysis will present great demands on your time, and you may feel as though your life has been taken over by your child's condition. Parents find that it eases the burden to share responsibilities. Other children in the family may become jealous of the attention that the sick child receives, particularly if dialysis is done at home. If this is a problem, it may be better to have dialysis treatments at a center.

Your entire family will probably need support during this difficult change in their lives. If you feel a need for professional help, or if you think someone in your family could benefit from talking with a social worker, a psychologist or other professional, your doctor can recommend someone. The kidney center will have a professional staff familiar with the special problems of children and their families.

Many children have trouble recognizing the seriousness of kidney failure because children seem to have a sense of immortality that adults do not share. If a child does not feel sick, he may have trouble accepting the need for treatment. You must be sure that your child is aware of the possible consequences of failing to follow treatments. Your child will cooperate more willingly if he is aware of the treatments that will come. If possible, arrange to visit a dialysis center before your child begins dialysis. Introduce him to the personnel at the center, and let your child see and talk with someone being dialyzed. If your child will be having a transplant, be sure he understands what is happening and has visited the hospital and become familiar with the environment. Allow your child the opportunity to develop an independent relationship with physicians and staff. He or she will then feel more secure when hospitalized and will take a greater responsibility for his own health care.

Adolescents have a great need to be part of the group, to be just like all their friends.

The adolescent with end-stage renal disease has special problems to overcome in his or her efforts to be one of the group. You should expect your child to feel anger and resentment towards the treatments, the doctor, and you. Encourage your child to express anger, depression, or other emotions he feels. If your child is angry, allow the anger to be expressed at you—you can help your child with emotional upsets more than anyone else can. Be open about your feelings, and encourage your child to share his feelings with you.

Watch your child's social development as carefully as you observe his health. Look for signs of loneliness and depression and for signs of poor adjustment, such as falling grades. You may not be able to solve your child's problems, but you can be of great assistance in helping him or her to deal with them. Make your child aware of your love and support, to help ease a difficult time.

MEDICAL PROBLEMS

Children with kidney failure face certain medical problems that adults with this condition do not. Kidney failure tends to stunt growth and development, particularly in children who have not reached puberty when the kidneys fail. Because transplantation is much more successful than hemodialysis for children, one of the goals of treatment for a child with end-stage renal disease should be a successful transplant.

Children may have problems with the fistula or shunt that adults with kidney failure do not experience. Children may be less careful of the shunt than adults, and may damage it or may fail to notice clotting. Children's veins are narrower than adults' and collapse more easily, making necessary the relocation of a fistula more often, perhaps every year.

If a child is on hemodialysis, a high-calorie diet will be prescribed to stimulate growth

and development. Although there may be certain forbidden foods, treat the diet as a natural part of your child's life. Children more readily accept dietary restrictions that are presented as natural and necessary.

The same is true of restrictions on physical activity. You should be aware of and understand the reasons for any restrictions your doctor has placed on your child's activity. This will help you in two ways: you will know what activities to advise against and you will be able to avoid restricting your child unnecessarily.

There are several ways you can help prevent medical problems. One is to become a conscientious observer of your child's health. Know the symptoms that indicate you should call your doctor immediately: nausea, vomiting, diarrhea, headache, dizziness, dimness of vision, convulsions, extreme fatigue, and any other signs that your kidney specialist asks you to watch for. Call your doctor as soon as you suspect something is wrong.

Also be sure that your kidney specialist is informed of all treatment your child receives from other doctors. Any medications your child receives can affect his needs in hemodialysis. Similarly, your family physician should be kept informed of the kidney specialist's treatments and decisions.

FINANCIAL AID

The personnel at your dialysis center can provide information about financial aid for children with kidney failure. Available assistance varies in each state, and some states have aid available to children that is not available to adults. The Bureau for Handicapped Children or the equivalent agency in your state is a source of information on insurance and financial aid. In addition, financial aid is sometimes available for the educational needs of children with end-stage renal disease.

Quality Assurance and Medical Information

APPROPRIATE CARE of patients who, like you, have end stage renal disease requires that many different types of services be readily available when needed. Such services include training for self-dialysis, support for home dialysis patients, self-dialysis in a dialysis facility, maintenance dialysis, in-hospital dialysis for back-up of dialysis patients, kidney transplantation, tissue typing, and a registry of patients awaiting transplantation. Because a single facility may not provide all of these services, networks of facilities have been formed so kidney disease patients are assured of the availability of appropriate treatment. For instance, the facility where you are presently being treated belongs to a network that contains at least two hospitals that are approved to do transplantation and at least one facility that is approved to train patients for self-dialysis.

A Network Coordinating Council and a Medical Review Board have been established for the facilities in your network for the purpose of coordinating the provision of patient care and to assure the highest possible quality of medical care. At least three members of this council will be consumer representatives whose role is to serve as your voice at meetings. The other members of this council will be physicians and health personnel involved in the care of kidney patients. Your doctor or medical facility can provide more information about these functions. The U.S. Department of Health, Edu-

cation, and Welfare also has information about the program which can be obtained by writing to the ESRD Program, Bureau of Quality Assurance, 5600 Fishers Lane, Rockville, Maryland, 20852.

As a further aid in the assessment of the quality of care delivered to patients with end-stage renal disease, a National End-Stage Renal Disease Medical Information System has been established. This information system contains data on each patient who receives end stage renal disease services. The data on individual patients is considered confidential and is supplied to the information system by the patient's physician on standardized forms at monthly intervals. It includes information about the treatment the patient is currently receiving and that which is planned in the future; about the amount of time the patient has had to spend in the hospital each year; about medical complications the patient is experiencing; and about the manner in which these are being treated.

By analyzing this information it will be possible to develop data so that the course of an individual patient or performance of an individual facility can be compared to professionally established criteria for determining quality end stage renal disease care. Such comparisons will be updated yearly and made available to all interested parties. Your physician will have this data available and can discuss its implications for your present care and future plans with you.

A Case History

TO HELP YOU REVIEW the methods of diagnosis and treatment of end-stage renal disease, a fictitious case history is presented below. It follows the experiences of Joseph Andrews from the time his kidney disease was detected until his second transplant. After each section of the history, the methods of payment that were available to Mr. Andrews are discussed.

DETECTION, DIAGNOSIS, AND EARLY TREATMENT OF KIDNEY DISEASE

Joseph Andrews, a 43 year old welder at an automobile plant, was seeing his family physician for a routine physical examination. Although he was experiencing no symptoms, laboratory tests indicated that Mr. Andrews had lost almost 50 percent of his kidney function. Mr. Andrews' doctor gave him the name of a kidney specialist and told Mr. Andrews to make an appointment immediately.

Since he felt well, Mr. Andrews did not think his problem was nearly as severe as his doctor made it sound, and he put off calling the kidney specialist for several days. When Mr. Andrews finally saw the kidney specialist, Dr. Hauser, several tests were made immediately and a kidney biopsy was recommended. A biopsy, in this case, refers to removal of a very small part of the kidney for examination. Dr. Hauser explained kidney function and the effects of kidney disease to Mr. Andrews, who then began to recognize the seriousness of his disease. Dr. Hauser gave Mr. Andrews several publications on kidney disease and its treatment, and he began studying the subject.

After the biopsy operation, Dr. Hauser told Mr. Andrews that he had glomerulonephritis, an inflammation of the kidneys. Dr. Hauser told Mr. Andrews that his condition would eventually lead to kidney failure, and at which point he would need either hem-

dialysis or transplantation. Until kidney failure occurred, Mr. Andrews' kidney disease could be treated with medications.

Five months after the biopsy, Mr. Andrews' kidneys were functioning at only ten percent of normal. Peritoneal dialysis was begun, and Mr. Andrews followed a carefully controlled diet plan. He ate very little sodium and a measured amount of protein. Mrs. Andrews met with the hospital's dietitian several times to work out an appropriate diet plan and learned how to make food taste good by using herbs and spices she had never tried.

Method of Funding for Detection, Diagnosis, and Early Treatment of Kidney Disease

- Mr. Andrews' doctor and hospital bills were paid by his health insurance coverage and with funds from his savings.
- If Mr. Andrews were 65 years of age or older, he probably would have been partly covered by Medicare.
- If Mr. Andrews had qualified for medical assistance based upon minimum income requirements, he might have been entitled to receive benefits through a state program.
- If Mr. Andrews had been a member of a prepaid health insurance program, his care might have been covered through the program.

PREPARATION FOR TREATMENT OF END-STAGE RENAL DISEASE

The entire medical team helped prepare the treatment plan for Mr. Andrews. Dr. Hauser explained to Mr. Andrews that if he chose dialysis, he would probably need two or three treatments a week, each lasting about five hours. The social worker pointed out some changes this would bring about in Mr. Andrews' life. For instance, if he chose dialysis in a center, he would have to be

away from home two or three evenings every week. Mr. Andrews said that if he began a program of ongoing hemodialysis, he much preferred performing home dialysis with his wife's help.

Dr. Hauser explained what he saw as the advantages of a kidney transplant over hemodialysis: Mr. Andrews could have more normal activity and diet; he would not experience the complications of hemodialysis; and in the long run transplant would be less expensive. Mr. Andrews agreed that he would prefer transplantation and asked that tissue-typing be done on himself and his sister, who had volunteered to donate a kidney if it became necessary.

A transplant surgeon examined Mr. Andrews' sister and determined that she had no kidney disease. Extensive tissue-typing studies determined that there was a good tissue match between them, and the transplant surgeon recommended that transplantation be performed when Mr. Andrews' kidneys had failed to the point where hemodialysis or transplantation would be required to sustain his life.

Dr. Hauser and the transplant surgeon decided to create an access route to Mr. Andrews' blood system, should hemodialysis be required before or after the transplant. Mr. Andrews said that he preferred an internal fistula to an external shunt. Two months before the estimated time of the transplant, he had surgery to create the internal fistula in his arm.

Methods of Funding for Preparation for Treatment of Permanent Kidney Failure

- Mr. Andrews did not qualify for Medicare because a course of hemodialysis had not started, nor had a transplant occurred.
- Mr. Andrews' insurance covered the cost of fistula surgery.
- Mr. Andrews' insurance policy was broad in coverage and included the cost of evaluating his sister for tissue-typing and kidney function.

(Not all insurance policies have this broad coverage.)

TRANSPLANTATION

For several weeks before the transplant operation, Mr. Andrews had been feeling tired. He had to take several days off from work to rest, and was thinking about looking for a less strenuous job. Dr. Hauser told Mr. Andrews that he could expect to regain most of his energy after the transplant, and Mr. Andrews decided to keep his welding job until then.

When complete kidney failure occurred, Mr. Andrews and his sister were operated on simultaneously in adjacent operating rooms. One kidney was taken from his sister and transplanted into Mr. Andrews. Medications were given to Mr. Andrews during hospitalization and afterward to prevent rejection of the transplanted kidney. Mr. Andrews was in the hospital for about four weeks.

Mr. Andrews came home from the hospital with appointments for blood tests twice a week as an outpatient and appointments with the transplant clinic once a week. Although Mr. Andrews felt well at the end of his hospitalization, he did not return to work until eight weeks after surgery. Mr. Andrews' sister was discharged from the hospital ten days after surgery and was back at work seven weeks after the operation.

Method of Funding for Transplantation

- Medicare Hospital Insurance paid all of the covered hospital services, except for the first \$92 for Mr. Andrews. It paid all of his sister's costs covered by Medicare Hospital Insurance.
- Twelve months after the transplant operation, the transplanted kidney was functioning normally, and Medicare coverage ended.

REJECTION OF TRANSPLANT AND BEGINNING OF HOME DIALYSIS

Thirty-six months after the transplant operation, Joseph Andrews' doctor discovered that the kidney was being irreversibly rejected by his body. His surgeon removed the transplanted kidney. After surgery, he

was extremely sick, and was hospitalized for three weeks. During this hospitalization, he had ten hemodialysis treatments.

Because he felt depressed after the removal of the kidney, Mr. Andrews arranged a meeting with a psychologist at the hospital. The psychologist explained that depression, a normal reaction after major surgery, was aggravated in Mr. Andrews' case by disappointment about the kidney rejection. Mr. Andrews was feeling better two weeks after the operation.

Mr. Andrews still felt that he would be much happier with a home dialysis program, so he and his wife began a six-week course on home dialysis at a local dialysis center.

Before the kidney rejection, Mr. Andrews was promoted to a supervisory job that required less physical labor. Although he felt tired during the time he was on hemodialysis, his new job was less demanding physically, and he was able to maintain a forty-hour weekly job schedule.

Mr. Andrews was having three home dialysis treatments a week in the evenings, each lasting six hours. By listening to the family stereo and reading interesting books, he felt he was making the most of the time. Also, friends frequently visited him during the treatments.

Mr. Andrews had monthly appointments at the dialysis center for physical examinations and a review of his records to be sure that he was not experiencing complications. Except for his fatigue, Mr. Andrews had no complaints about his health.

Method of Funding for Rejection of Transplant and Beginning of Home Dialysis

- Mr. Andrews will become eligible for Medicare the first day of the calendar month after the month in which he began the current course of dialysis following rejection of the transplant.

- The dialysis was covered under Medicare Medical Insurance (Part B). (Mr. Andrews paid his \$6.70 monthly medical insurance premium.) Medicare paid 80 percent of the allowable charges, except for the \$60.00 deductible.

SECOND TRANSPLANT

Although Mr. Andrews was doing well on hemodialysis, his name remained on the waiting list for transplant with an unrelated donor's kidney. Four months after the first kidney had been rejected, a donor kidney became available in a transplant center 120 miles from Mr. Andrews' home. Transplant surgery was performed six hours after Mr. Andrews arrived at the hospital, and good function was achieved.

Mr. Andrews continues to take medications to prevent rejection of the second kidney. Because these medications make him more susceptible to infection, he must be very careful to avoid colds, flu, and other common infections. He now eats a normal diet and exercises regularly to maintain his health which helps to prevent infection. He still has frequent blood tests to check for rejection, but they are scheduled for Saturdays and during evening hours so that he and his wife don't have to take time off from work.

Method of Funding for Second Transplant

- Medicare Hospital Insurance paid for the hospitalization, as it did for the first transplant.
- Twelve months after the successful transplant, Mr. Andrews' Medicare coverage will end. If he requires dialysis in the future, or undergoes repeat transplantation, he will need to reapply for Medicare benefits.

Glossary

ABDOMINAL CAVITY: The area in the lower part of the trunk of the body that contains the urinary and digestive systems, and is encased by the peritoneal membrane.

ACUTE KIDNEY FAILURE: A sudden and possibly fatal stopping of the kidney function, which can occur in a matter of hours or days.

ACUTE TUBULAR NECROSIS: Sudden cessation of kidney function (one's own kidneys or a transplant) due to impaired blood supply or chemical injury.

ANEMIA: A condition in which there is a reduction in the number of circulating red blood cells. Anemia causes paleness, weakness, and fatigue, among other symptoms.

ANTICOAGULANTS: Medications used to help prevent blood clotting.

ARTERY: Vessel carrying blood away from the heart. Part of the circulatory system.

ARTIFICIAL KIDNEY MACHINE: Hemodialysis machine. A machine through which a patient's blood is circulated in order to maintain the chemical and fluid balance of the body.

BATCH SYSTEM: A method of supplying dialysate that involves the preparation of a large amount of dialysate by mixing concentrated chemicals with large amounts of purified water.

BLADDER: The sac in which urine produced by the kidneys is collected and stored until the urine is released from the body.

BLOOD PRESSURE: Pressure of the blood flowing through the blood vessels.

CADAVER: Body of someone who has died.

CALCIUM: A mineral found in the blood that is important to the body's functioning.

CANNULAE (singular = CANNULA): Special tubes that carry blood from an artery directly to a nearby vein.

CAPILLARY KIDNEY: A dialyzer consisting of thousands of tiny plastic tubes lying parallel to each other.

CATHETER: A plastic or rubber tube through which fluids enter or leave the body. A Foley catheter is used to withdraw urine from the bladder.

CHRONIC KIDNEY FAILURE: The slow destruction of normal kidney tissue that occurs over months or years, and results in End-Stage Renal Disease.

COIL DIALYZER: Dialyzer in which the cellophane membrane is in the form of a long tube coiled in a spiral. Blood flows through the tube and dialysate flows around it.

CONNECTOR: The tube that carries blood from one cannula of a shunt to the other cannula while the patient is not on hemodialysis.

CREATININE: A metabolic endproduct, not needed by the body.

DIALYSATE: The solution used in an artificial kidney machine to remove excess fluids and metabolic endproducts from the blood.

DIALYSATE SUPPLY SYSTEM: That part of the hemodialysis machine that provides a steady flow of dialysate during hemodialysis.

DIALYSIS: Process of maintaining the chemical balance of the blood when the kidneys have failed. May refer to hemodialysis or peritoneal dialysis.

DIALYZER: That part of the hemodialysis machine that contains the cellophane membrane through which blood passes during hemodialysis.

DIFFUSION: Passage of particles from a

solution of high concentration to a solution of low concentration.

END-STAGE RENAL DISEASE (ESRD): That stage of kidney impairment that requires dialysis or kidney transplantation or both to maintain life and health.

END-STAGE RENAL TREATMENT: Refers to either dialysis or kidney transplantation, or both forms of therapy.

EDEMA: Swelling in a specific area of the body due to retention of excess fluids.

FISTULA: A connection made between an artery and a vein in an arm. Sometimes the connection is made between an artery and a vein in a leg. A fistula, which is made through surgery, causes the vein to become larger so that needles can be easily inserted to connect the patient to the hemodialysis machine.

GLOMERULONEPHRITIS: A disease involving inflammation of the tissues of the kidneys.

GRAFT: A transplanted organ.

HEMATOCRIT: A measure of the amount of red blood cells in the blood.

HEMODIALYSIS: The use of an artificial kidney machine to maintain the chemical balance of the body.

HYPERKALEMIA: A high level of potassium in the blood that can cause irregular heartbeat and ultimately cardiac arrest. It is a potential problem for people on hemodialysis.

HYPERTENSION: High blood pressure. Some cases of hypertension can result in kidney damage.

HYPOTENSION: Low blood pressure. A potential problem during hemodialysis treatments.

IMMUNOSUPPRESSIVE MEDICATIONS: Drugs taken to help prevent rejection of a transplanted kidney. Also cause weakening of the body's system of defense against infection.

KIDNEY: One of two organs located at the back of the abdominal cavity, one on each side of the spinal column. Their function is to maintain the chemical balance of the body.

KIDNEY TRANSPLANT: The taking of a kidney from the body of one person and implanting it surgically in the body of someone who has lost kidney function, to perform the function of that person's kidneys.

LIMITED CARE FACILITY: A dialysis unit where patients who are not trained in the technique of dialysis are treated by a trained professional staff. The unit is usually not located inside a hospital.

METABOLIC ENDPRODUCTS: Chemicals produced by normal body functions that are not needed by the body.

NEPHROLOGIST: A physician primarily concerned with treatment of patients with impaired kidney function.

NEPHRON: The functional unit of the kidney which acts to maintain the body's chemical balance. There are approximately 1,000,000 nephrons in each kidney.

NEUROPATHY: Refers to any disease of the nerves. Sensitivity of the nerves is usually decreased as a result.

OSMOSIS: The passage of fluid through a membrane separating solutions of varying concentrations. The fluid passes through the membrane from the region of lower concentration of dissolved substance to the region of higher concentration of a dissolved substance. The two solutions tend to reach equal concentrations.

PARALLEL FLOW DIALYZERS: A type of hemodialysis machine consisting of layers of membrane arranged one on top of the other.

PARATHYROID GLAND: One of several small endocrine glands located in or around the thyroid gland in the neck. These glands secrete a hormone which regulates calcium-phosphorus metabolism.

PERITONEAL DIALYSIS: A process in which dialysate is introduced into the abdominal cavity. The peritoneal membrane in the abdomen functions in the same way that the cellophane in the hemodialysis machine functions.

PERITONEUM: The membrane lining of the abdominal cavity.

PERMANENT KIDNEY FAILURE: Irreversible loss of kidney function. At this stage of kidney failure, dialysis and/or kidney transplantation is needed to maintain life and health.

POLYCYSTIC KIDNEY DISEASE: A hereditary disease involving slow destruction of functioning kidney tissue over twenty to forty years.

POTASSIUM: A mineral necessary to the body, but harmful when found in excess. Hyperkalemia is a condition in which there is an excess of potassium in the body.

PROPORTIONING SYSTEM: Equipment designed to mix automatically and continuously a concentrated dialysate solution with purified water during a treatment.

PULMONARY EDEMA: A condition in which the body retains excess fluid, causing the heart to pump more blood from the lungs into the general circulation than it is able. This can result in excess blood in the lungs and the eventual filling of some of the airways of the lungs with fluid. Treatment consists of removal of fluid during dialysis, restriction of fluid intake, reduction of blood pressure, and other measures.

REGIONAL HEPARINIZATION: A method of giving anticoagulant medication during hemodialysis that involves adding heparin (the anticoagulant) to the blood as it leaves the body, and neutralizing the heparin before it returns to the bloodstream.

RENAL: Refers to kidney.

SELF-CARE UNIT: Any outpatient facility where a properly trained patient can dialyze himself with little or no professional supervision.

SHUNT: A surgically prepared, external connection made between an artery and a

vein. The external connection between artery and vein is made with plastic tubing which extends from vessels through two small openings in the skin. The plastic tubes from each vessel are then connected end-to-end and lie close to the skin.

SODIUM: A mineral found in the body which helps regulate the fluid content in the body. Also found in many foods.

TISSUE-TYPING: Laboratory procedure used to determine the degree of compatibility between the donor organ and the recipient of the kidney transplant.

TRANSPLANTATION: The surgical procedure that involves taking an organ from either a cadaver or from a living relative of the patient and implanting it in the patient.

ULTRAFILTRATION: The method used to remove excess fluids from the blood during dialysis. A pump is used to raise the pressure of the blood above that of the dialysate, and fluids are forced out of the blood.

UREA: A metabolic endproduct not needed by the body.

UREMIA: Toxic condition associated with loss of kidney function and the retention of metabolic endproducts in the blood. The symptoms are weakness, nausea, itching, sleep disturbances, impaired memory, and confusion.

URETER: One of two tubes within the body that carries urine from the kidneys to the bladder.

URETHRA: A canal for the discharge of urine.

UROLOGIST: A physician primarily concerned with the diagnosis and treatment of disorders of the urinary system.

VEIN: A vessel carrying blood to the heart. Part of the circulatory system.

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